This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.
+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.
+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.
+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

B 3 840 589

LIBRARY.
OF THE
UNIVERSITY OF CALIFORNIA.
RECEIVED BY EXCHANGE
Class

BERKELEY
LIBRARY
UNIVERSITY OF
CALIFORNIA

EARTH
SCIENCES
LIBRARY

431 c

PART I. VOL. XXV.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

EDITED BY

THE HONORARY SECRETARIES.

SESSION 1896-97.

SOLD AT THE ROOMS OF THE SOCIETY,
QUEEN'S CHAMBERS, 5, JOHN DALTON STREET, MANCHESTER.

MDCCCXCVII.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

EDITED BY

THE HONORARY SECRETARIES.

VOLUME TWENTY-FIFTH.

PARTS I.—XXI.

FOR SESSIONS 1896-7, AND 1897-8.

MANCHESTER:
SOLD AT THE ROOMS OF THE SOCIETY,
5, JOHN DALTON STREET, MANCHESTER.
MDCCCXCVIII.

EARTH
SCIENCES
LIBRARY

EXCHANGE

** The writers of papers alone are responsible for the facts and opinions contained in their respective communications.

UNIV. OF
CALIFORNIA

CONTENTS OF VOLUME XXV.

	PAGE
New Member	1
Annual Meeting and Report of the Council for 1895-96	1
Balance Sheet—Abstract for 1895-96	5
List of Papers and Short Communications, Session 1895-96..	11
Members—New, Honorary, Deceased, and Resigned, 1895-96	12
List of the Council for 1896-97	13
Presentations to the Library, 1895-96	14
Societies with which the Society exchanges its Transactions, and Institutions and Journals to which a copy is sent free	21
Past Presidents of the Society	26
List of Members, October, 1896	27
The International Congress of Geologists	37
Donations to the Library..	38
Presidential Address: The early history of the Manchester Geological Society, with some remarks on Speculative Geology. By Mark Stirrup, F.G.S.	39
New Members..	69
Further Remarks on the Durham and Cleveland Salt Districts. By Thomas Bell, J.P.	69
On Irruptions of Coal into the "Thick Coal" Workings at Hamstead Colliery, South Staffordshire. By Frederick G. Meachem, M.E.	83
Remarks on some interesting Coal Measure Sections in the Leicestershire and South Derbyshire Coalfield. By W. S. Gresley, F.G.S., F.G.S.A.	95
Report of the Delegate to the Meeting of the British Association at Liverpool, September, 1896. By Mark Stirrup, F.G.S.	105

232204

PAGE

Boring for Coal at Bold, near St. Helens. By Henry Hall, H.M.I.M. 112

Evening Meeting 113

Some Experiments with regard to effects of pressure upon decaying vegetable matter. By J. Barnes, F.G.S., and W. F. Holroyd, F.G.S. 114

On the Occurrence of a Sea Beach at Castleton, Derbyshire, of Carboniferous Limestone Age. By J. Barnes, F.G.S., and W. F. Holroyd, F.G.S. 119

New Members 133

The Effects of Pressure on Vegetable Matter 134

The Improved Fleuss Breathing Apparatus. By George H. Winstanley, F.G.S. 137

New Members 153

Gifts to the Library, and Notices 153

On the History of the Discovery of the South Eastern Coalfield. By Prof. W. Boyd Dawkins, M.A., F.R.S., etc. 155

Earthquake Tremors. By William Watts, F.G.S. 164

Notes on the recent Slipping Peat in Ireland. By William Watts, F.G.S. 165

On Evidences of Glacial Action in Australia. By Bernard Hobson, M.Sc., F.G.S. 173

Evening Meeting: Further Notes on the Sea Beach in Carboniferous Limestone, Derbyshire. By J. Barnes, F.G.S., and W. F. Holroyd, F.G.S. 181

On the Occurrence of Lamellibranchiata, Gasteropoda and Cephalopoda in the Millstone Grit of South Yorkshire. By J. Barnes, F.G.S., and W. F. Holroyd, F.G.S. .. 184

The Effects of Marine Erosion, as shown by the sea cliffs and sea caves of the British Isles. By Mark Stirrup, F.G.S. 192

Flooding of a Colliery Shaft at Dover. By Joseph Dickinson, F.G.S. 193

PAGE

International Geological Congress at St. Petersburg 194

On the Increase of Fan Gauges in Mine Ventilation of the present day; with some Notes on Ventilators. By Rev. G. M. Capell 194

On the Permo-Carboniferous Boundary. By C. E. De Rance, Assoc.M.Inst.C.E., F.G.S., etc. 207

New Members 237

Notes on the Sinking at the Maypole House Colliery, Abram; with Specimens of the Rock, and an Analysis of the Water found in the Shafts. By George Caldwell .. 238

Notes on the Yorkshire Coalfield. By Richard Sutcliffe .. 246

Exhibition of Photographs, Prints, etc. By S. S. Platt, M.I.C.E., F.G.S. 255

New Member 257

Detonators and Detonation. By W. J. Orsman, F.I.C., F.C.S. 257

A New Hydraulic Apparatus for breaking down Coal in Mines. By James Tonge, C.E., F.G.S. 267

New Members 273

The Rock Salt deposits of Northwich, Cheshire, and the results of their exploitation. By Thomas Ward, J.P., F.G.S. Part I. 274

Notes on Messrs. Barnes and Holroyd's paper on "A Sea Beach at Castleton." By Prof. Hull, F.R.S., F.G.S... 306

Reply to Prof. Hull's Criticism. By J. Barnes, F.G.S., and W. F. Holroyd, F.G.S. 308

Annual Meeting and Report of the Council for 1896-7 .. 313

Balance Sheet for 1896-7 318

Election of Officers for 1897-8 319

New Members 321

Honorary Member. Mr. George Wild.. 321

List of Papers and Short Communications, 1896-7 325

PAGE

Members—New, Deceased, Resigned, 1896-7 327

Circular Letter of May, 1897 328

List of Council for 1897-8 329

Presentations to the Library, 1896-7 330

Societies with which the Society exchanges its Transactions and Institutions and Journals to which a copy is sent free 337

Past-Presidents of the Society 343

List of Members, October, 1897 344

The late Mr. James Heywood, F.R.S. 357

Election of Mr. George Wild as Honorary Member 359

New Members 360

Fossil Fishes from the Jarrow Colliery, Ireland 360

President's Address: The utility of Association for the Promotion of Science, and its Applications. By John Ridyard, F.G.S. 363

New Members 378

On the Correlation of the Dover and Somersetshire Coal-fields. By G. C. Greenwell, F.G.S., M.Inst.C.E. .. 378

Notes on Hematite found in the Maypole Sinking Pits. By George Caldwell 393

Fossils from the Carboniferous Limestone. Exhibited by J. Barnes, F.G.S., and W. F. Holroyd, F.G.S. 394

New Members 397

Further Notes on Irruptions of Coal into the "Thick Coal" Workings at Hamstead Colliery. By Frederick G. Meachem, M.E. 398

The Patent Hydraulic Mining Cartridge. By James Tonge, C.E., F.G.S. 405

On an improved appliance for drawing timber in Mines. By D. H. F. Mathews, H.M.I.M. 414

PAGE

Recent additions to the Manchester Museum. By Prof. W. Boyd Dawkins, F.R.S., etc. 421

Minerals from the Nickel Mines of Sudbury, Ontario. By W. E. Hoyle, M.A., F.R.S.E. 426

The Nomenclature of the Seams of the Lancashire Lower Coal Measures. By Herbert Bolton, F.R.S.E. 428

New Members 473

On the Mineral Resources of the Middleburg District, Transvaal, South Africa. By Herbert Lloyd, C.E., M.E... 474

Notes on Electrical Shot-firing. By H. Bigg-Wither 483

On the occurrence of supposed Calcareous Tufa in the Interglacial Deposits of Blackpool. By Robert Humphrey, F.S.A., (Scot.).. 494

Report on the recent International Geological Congress at St. Petersburg, with Sketch of the Geology of Finland. By Mark Stirrup, F.G.S. 501

New Members.. 509

Discussion on Mr. G. C. Greenwell's Paper on "The Correlation of the Dover and Somersetshire Coalfields" 510

New Aspects of Coal Bed Formation. By W. S. Gresley, F.G.S., F.G.S.A. [Abstract] 525

New Member 529

On the Rock Salt Deposits of Northwich, Cheshire, and the result of their Exploitation. Part II. By Thomas Ward, J.P., F.G.S., ... 530

Gifts to the Society 568

New Members.. 569

On the Coal Industry of the Rhenish-Westphalian Provinces. By Henry Hall, H.M.I.M... 569

PAGE

On an improved Decking Table for facilitating the loading of Pit Cages. By William Saint, H.M.I.M. 577

New Member 581

Fossil Remains in the Lancashire Coalfield 581

Map of Navigable Waterways 583

Subsidence caused by Colliery Workings. By Joseph Dickinson, F.G.S. 583

ERRATUM :—In the plate in Part XXI., Vol. XXV., illustrating Mr. Dickinson's Paper, the third line from the bottom, in the right hand corner, should read "Hard Strata, about 1 in 5 perpendicular" instead of "1 in 3 perpendicular."

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART I. VOL. XXV. SESSION 1896-97.

The ANNUAL MEETING of the Members was held at the Society's Rooms, Queen's Buildings, John Dalton Street, Tuesday, October 13th, 1896.

The President, Mr. R. WINSTANLEY, C.E., in the Chair.

NEW MEMBER.

Mr. WILLIAM TURNER, of Sherdley Colliery, St. Helens, was elected an ordinary member of the Society.

Mr. JAMES TONGE, one of the Hon. Secretaries, read the Fifty-eighth Annual Report, as follows:—

REPORT OF THE COUNCIL,

FOR SESSION 1895-1896.

The Council have pleasure in presenting the Fifty-eighth Annual Report of the Society.

MEMBERSHIP.—During the past year we have lost three members by death, nine by resignation, and one has been removed from the list. Ten new members have joined the Society.

The three gentlemen whose deaths we have regretfully to record are Mr. Thomas Edmondson, of Cliviger Collieries, Burnley; Mr. Thomas Grundy, of Abram; and Mr. Atherton

Selby, of Atherton, who had been a member of the Society for the long period of thirty years.

The total membership now stands as follows :—

Life Members	9
Honorary Members	12
Ordinary Members	208
Total	229

It will be noticed that we have now twelve honorary members, as against eleven last year,—our late honorary and honoured Treasurer, Mr. H. M. Ormerod, having been unanimously elected to that class.

Meetings.—The usual number of ordinary meetings have been held with a slight change in the order.

Two evening meetings have been held, one at the Society's rooms, when an address was given by Mr. Mark Stirrup, F.G.S., and one at the Owen's College, when Professor W. Boyd Dawkins, F.R.S., &c., addressed the members.

Only one meeting has been held in Wigan this year; a misunderstanding having arisen as to an expected paper.

The annual meeting and six ordinary meetings have also been held in the Society's rooms.

Papers.—The papers read before the Society have been chiefly of a geological character; and the Council may confidently say that the character and quality of the papers, and the interest taken in them as evidenced by the large attendances, have been fully equal to those in any former year. Some of the increase may be attributable to the introduction, by the President, Mr. R. Winstanley, of the oxy-hydrogen limelight for the purpose of illustrating the papers; the chief point of interest has, however, in most cases, been the paper itself.

The President opened the session with an admirable address entitled "A few thoughts on Geology," describing

and shewing by lantern slides geological forms in almost every geological age.

Mr. Mark Stirrup, F.G.S., at the evening meeting in November, read a paper on "The work of Subterranean Waters, Recent Explorations of Swallow Holes, Caverns, and Watercourses in the Limestone Districts of France," illustrated by high-class lantern slides from views taken by M. Martel, of Paris.

Mr. Stirrup also read a paper at the March meeting, by Mr. Kinahan, M.R.I.A., on "Possible land connections in recent Geological times between Ireland and Great Britain;" and in April another paper by Dr. Stainier, of the Geological Survey of Belgium, on "Pebbles found in Belgian Coal Seams."

At the evening meeting in February, held at the Owens College, Professor W. Boyd Dawkins, F.R.S., &c., gave in his customary happy style a short but interesting discourse on some recent additions to the museum.

In April, Mr. Joseph Dickinson, F.G.S., contributed a useful paper on "River Valleys," the principal object being to show that rivers ordinarily flow from older to newer geological formations, as illustrated by the principal rivers of England.

Mr. H. Hall, H.M.I.M., at the same meeting, exhibited and described a safety lamp with a novel arrangement for re-lighting without opening the lamp.

Mr. H. Bolton, F.R.S.E., in November gave a very interesting paper, illustrated by lantern slides, on "The Geology of North-East Lancashire in its relation to the Physical Geography of the District."

At the Wigan meeting in May, Mr. C. M. Percy brought to the notice of members, in a paper entitled "Safety in Colliery Winding," several important points in connection with the subject, and gave a detailed description of the

safety appliance known as the "Visor," an automatic arrangement for shutting off steam and applying the engine brake in the event either of the engine starting the wrong way or of the cage coming up at too great a speed.

At the same meeting, Mr. Eddleston exhibited and described a new arrangement of double catches to receive the cage in the event of an overwind.

Messrs. Holroyd and Barnes contributed, at the February meeting, a detailed paper on "The Rocks and Fossils of the Yoredale Series of the Marsden and Saddleworth Valleys," which was illustrated by diagrams, lantern slides, and numerous fossils. At the March meeting they read a second paper on "The Stratified Clay of Strathearn, and of the Imatra or 'Fairy Stones' found therein," illustrated by specimens. In April they showed a number of well-preserved Eocene and Miocene fossils from the Paris basin, and in June they contributed an exhaustive paper on "The Mountain Limestone Caverns of Tray Cliff Hill, Castleton, Derbyshire, with some of their contained minerals." They also led a geological excursion in July to the district of the Marsden and Saddleworth valleys, to which their first paper related. The Society has also been presented with a number of "Memoirs on Belgian Geology," by Dr. Stainier, per Mr. Mark Stirrup. The President also showed Permian fossils from the shafts now being sunk by Mr. George Caldwell and partners in the township of Abram. Numerous verbal communications of interest were also made at various times by members of the Society.

In conclusion, the Council would again remind members that the rooms, Queen's Chambers, 5, John Dalton Street, are open daily, and they will be pleased to see them used by the members at their convenience.

Mr. Tonge also read the Treasurer's Statement of Accounts for the past year:—

Dr. MANCHESTER GEOLOGICAL SOCIETY.—BALANCE SHEET. *Cr.*

Abstract of Receipts.	£	s.	d.
To Balance from last year	137	12	1
,, Bank Interest	0	6	5
,, Birkenhead Railway Dividend	11	12	0
,, ,, ,, ,,	11	12	0
,, Lancashire & Yorkshire Railway Dividend	10	12	8
,, ,, ,, ,, ,,	10	12	8
,, Colliery Managers Association—Rent of Rooms	1	0	0
,, Subscriptions and Arrears	180	10	0
,, Transactions sold	0	16	6
,, W. G. Black, F.R.C.S.E.—Subscription towards Expenses of Removal	1	2	0
,, Balance due to Treasurer	6	8	0
	£372	4	4

The Investments consist of £600 Four per cent. Guaranteed Stock of the Birkenhead Railway Co., and £550 of Lancashire and Yorkshire Consolidated Four per cent. Preference Stock.

Abstract of Payments.	£	s.	d.
By Library	5	14	6
,, Transactions	57	1	4
,, Reporters	9	9	0
,, Circulars and Stationery	17	9	10
,, Postages	13	13	6
,, Collectors' Commission	9	1	7
,, Rent, Rates, Light, Water, Fuel, and Attendance	102	11	5
,, Outside Meetings	1	8	9
,, Furniture and Removal	149	3	4
,, Insurance	1	5	0
,, Sundries	5	6	1
	£372	4	4

9th October, 1896.

CLEGG LIVESEY, Treasurer.

GEO. A. HOLLINGWORTH, } Auditors.
HERBERT A. WOODWARD, }

Mr. JOSEPH DICKINSON moved "That the Report and Statement of Accounts be adopted."

Mr. GEORGE PEACE seconded the motion, and it was unanimously passed.

The PRESIDENT said: The next business is the election of officers for the ensuing year. I have in my hand a list of the gentlemen recommended by the Council for election; and I have great pleasure in stating, in the first place, that they unanimously recommend Mr. Mark Stirrup for the office of President. His name, I am sure, will be received by the members with acclamation. Mr. Stirrup is an old member of the Society, and for several years he held the office of Honorary Secretary, and we know how his heart and soul have been in the work of this Society. I nominate him on behalf of the Council.

Mr. JOSEPH DICKINSON: I have great pleasure in seconding that nomination.

The PRESIDENT put it to the meeting, and it was carried by acclamation.

Mr. STIRRUP briefly thanked the meeting for his election, and expressed the hope that he might have the support of all the members during his year of office.

Mr. DICKINSON: I would like to say, with regard to Mr. Stirrup's election, that no man has ever earned the post of President more truly than he has done.

Mr. WINSTANLEY: I will now, gentlemen, read the names of those who are recommended by the Council for the other offices, and it may be your pleasure that they should be received *en bloc*. These, I may say, are the recommendations of the Council, but it is quite open to any individual member to propose other names. Vice-Presidents: Mr. George Peace, Mr. John Gerrard, H.M.I.M., Mr. S. S. Platt, F.G.S., and Mr. John Ridyard. *Ex-officio* Vice-Presidents as before, with the addition of Mr. R. Winstanley.

Honorary Treasurer: Mr. Clegg Livesey. Honorary Secretaries: Mr. James Tonge and Mr. William Saint. Other members of the Council: Messrs. W. N. Atkinson, J. Barnes, H. H. Bolton, J. Crankshaw, S. Garside, G. C. Greenwell, jun., G. B. Harrison, W. F. Holroyd, C. R. Lindsay, D. W. F. Matthews, G. H. Peace, and T. Scowcroft.

Mr. Clegg Livesey moved that the gentlemen whose names had been read should be elected officers and members of the Council for the ensuing year.

The motion was seconded, and unanimously agreed to.

On the motion of Mr. Platt, Messrs. Hollingworth and Woodward were re-appointed Honorary Auditors.

Mr. Holroyd said: I have great pleasure in proposing that the best thanks of the Society be given to the retiring President and Council for their services during the past year.

Mr. J. S. Burrows: I have pleasure in seconding that motion. We have had a pleasant and most successful year, and the President has shown himself all that we expected him to be in the chair.

Mr. Stirrup: I do not know whether our Honorary Secretaries ought not to be included in the resolution, because on them falls, as a rule, a large amount of the work of the Society.

With the assent of the mover and seconder the resolution was made to include the Honorary Secretaries, and upon being put to the meeting by Mr. Stirrup it was passed unanimously.

Mr. Winstanley briefly acknowledged the vote of thanks on behalf of himself and his colleagues on the Council, and afterwards invited Mr. Stirrup to take his position as the newly-elected President.

Mr. Stirrup thereupon took the chair. He said: Perhaps the Honorary Secretaries will state what prospects of papers

we have for the forthcoming Session. If any gentlemen present are prepared to give us papers, I am sure the Secretaries will be glad to take note of them.

Mr. Tonge, one of the Hononary Secretaries, said he should be pleased if gentlemen who were willing to read papers would give him early intimation.

The President (Mr. Mark Stirrup): I believe it is usual for the President of this Society, upon taking office, to prepare an address. That, I shall be glad to do, and will bring it before you at our next monthly meeting. I shall also be able, I dare say, to prepare some short report of the Liverpool meeting of the British Association, to which I was your delegate, but that report will be practically only a record of the progress of the different sciences as represented at the meeting. I have, besides, a short paper that has been sent to me by Mr. Gresley, who is now resident in Pennsylvania, the subject of which is entitled, "On some Coal Measure Sections in Leicestershire."

I should very much like to have, during the coming session, the more active co-operation of gentlemen—engineers and others—connected with the mining industry. Last session one of our Wigan meetings was not held for want of papers. I hope each member will take it to himself that he can help the Society materially by bringing matter before us for discussion. Members should scarcely consider that they have fulfilled all their duties to the Society when they have paid their subscriptions. They should endeavour to help the Society in other ways. Many of you, gentlemen, are connected with the coal mining or quarrying interest, and I am sure many a time observations are made above and below the surface of the ground that might be brought here for discussion, if not in the form of papers at any rate of brief notes. Communications of that sort not unfrequently appear in our Transactions, and may be found of even greater

interest and value in succeeding years. I hope with the concurrence of the Council also to see if we cannot get up two or three evening meetings during the session. It has been said that some of the members are not able to attend our afternoon meetings. Well, now that we have most comfortable rooms, I think it ought not to be impossible to employ them profitably on some winter evenings, by meetings of a social and conversational kind. By such means perhaps something may be done to interest members a little more in the work of the Society. The interest of the meetings might be increased by the introduction of lantern illustrations. By all means let us try to infuse a little more life and energy —a little more enthusiasm—into our proceedings. With a little generous assistance on all hands this may be done, and we shall be able to prove ourselves in earnest as a working Society. With regard to the address which I propose to give next month, I may say that it will embrace some account of the early history of this Society. It is now nearly sixty years ago—this is our fifty-eighth annual meeting—since the Society was formed, and to many of you no doubt—as they were to myself—many of the incidents of its early history must be totally unknown. It will be of interest to show what was the object of the founders of the Society. The facts I shall be able to derive from old minute books of the Society, which fortunately Mr. H. M. Ormerod was able to preserve when we removed from the old Natural History Society's building in Peter Street. I hope these facts and incidents may prove an incentive to members to keep the Society up to the standard which it attained in its best and earlier days.

Mr. Dickinson: I am sure, Mr. President, in speaking of gentlemen connected with coal mining, you did not mean to exclude those connected with other descriptions of mines.

The President: Certainly not.

Mr. Dickinson: Because there is sitting beside me a gentleman who represents the largest number of the rock salt mines in this kingdom. I hope Mr. Rigby will consider that he is included in the scope of your admirable address.

The President: Certainly; Mr. Dickinson will recollect that at our last Council meeting I mentioned specially some salt-mines—or rather some borings for salt—in the Isle of Walney; and I asked him if he could not get some particulars to bring before the Society. We have had from Mr. Ward, the Secretary of the Salt Union, and a member of this Society, several papers of a most interesting kind. Mr. Ward is now under a promise to give us a paper, and I hope we may have it during the coming session. Any communication from the gentleman to whom Mr. Dickinson referred would be most gladly received.

Mr. Dickinson: It was mainly to Mr. Rigby that we were indebted for that very valuable boring at Marston, a description of which was read before the Society by Mr. De Rance. Mr. Rigby did, I believe, undertake to give us the engineering part of it, and that undertaking is still in abeyance.

Mr. Rigby said that unfortunately the details could not be disclosed. The ordinary facts of salt mining were so commonplace that he did not think he could add anything of much interest.

The President assured Mr. Rigby that, even though unable to read a paper, his presence at the meetings and assistance in their discussions would always be most welcome to the members.

This concluded the business of the Annual Meeting.

LIST OF PAPERS AND SHORT COMMUNICATIONS

WHICH HAVE BEEN BROUGHT BEFORE THE

SOCIETY DURING THE SESSION 1895-6.

1895.

November. Winstanley, R. "A Few Thoughts on Geology."

Stirrup, Mark. "On the Work of Subterranean Waters.: Recent Explorations of Swallow Holes, Caverns, and Water Courses of the Limestone Districts of France.

December. Bolton, Herbert. "On the Geology of North-East Lancashire in its Relation to the Physical Geography."

1896.

February. Holroyd, W. F., and J. Barnes. "On the Rocks and Fossils of the Yoredale Series of the Marsden and Saddleworth Valleys."

Dawkins, Professor W. Boyd. "On Recent Additions to the Museum."

March. Winstanley, R. "On Permian and other Fossils from the Lancashire Coalfield." "On an Improved Disengaging Hook."

Holroyd, W. F., and J. Barnes. "On the Stratified Clay of Strathearn, and on the Imatra, or 'Fairy Stones,' found therein."

Kinahan, G. H. "On possible Land Connections in recent Geological Times between Ireland and Great Britain."

April. Hall, Henry. "On Self-igniting Safety Lamps."

Dickinson, Joseph. "River Valleys."

Stainier, X. "On the Pebbles found in Belgian Coal Seams." "Appendix." "Bibliography."

Holroyd, W. F. "Eocene and Miocene Fossils."

May. Eddleston, —. "On Patent Safety Hooks."

Hall, Henry. "On a Self-lighting Lamp."

Percy, C. M. "On Safety in Colliery Winding." "Appendix."

June. Barnes, J., and W. F. Holroyd. "On the Mountain Limestone Caverns of Tray Cliff Hill, Castleton, Derbyshire, with some of their contained Minerals."

NEW ORDINARY MEMBERS.

Atherton, H. Stanley
Coope, Samuel
Lomax, Charles
Matthews, Thomas
Mitton, A. Dury
Purdy, Richard
Rothwell, Samuel
Ryans, Joseph
Travers, T. W.
Wordsworth, T. H.

NEW HONORARY MEMBER.

H. M. Ormerod, F.G S.

MEMBERS DECEASED.

Edmondson, Thomas
Grundy, Thomas
Selby, Atherton.

MEMBERS RESIGNED.

Boyd, Alexander C.
Brown, John
Dobb, Thomas
Hedley, John L.
House, John
Lupton, Arnold
Mills, Albert
Newton, Charles E.
Ridings, George.

MEMBER REMOVED FROM THE LIST.

Harbottle, W. H.

The following is the complete list of the Council for the ensuing year:—

President:

MARK STIRRUP, F.G.S.

Vice-Presidents:

GEORGE PEACE. | JOHN GERRARD, H.M.I.M.
S. S. PLATT, F.G.S., Assoc.M.Inst.C.E.
JOHN RIDYARD, F.G.S.

Ex-Officio Vice-Presidents:

JAMES HEYWOOD, F.R.S. | R. CLIFFORD SMITH, F.G.S.
H. M. ORMEROD, F.G.S.
The Right Hon. the EARL OF CRAWFORD & BALCARRES.
Sir U. K. SHUTTLEWORTH, Bart.
EDWARD PILKINGTON, J.P.
Professor W. BOYD-DAWKINS, M.A., F.R.S., F.G.S.
JOSEPH DICKINSON, F.G.S.
G. C. GREENWELL, F.G.S., M.Inst.C.E.
HENRY HALL, H.M.I.M. | JOHN S. BURROWS, F.G.S.
JAMES TONGE, F.G.S., Assoc.M.Inst.C.E.
W. SAINT, H.M.I.M. | W. WATTS, F.G.S.
ROBERT WINSTANLEY, C.E.

Hon. Treasurer:

CLEGG LIVESEY, J.P.

Hon. Secretaries:

J. TONGE, F.G.S., C.E. | WILLIAM SAINT, H.M.I.M.

Other Members of the Council:

W. N. ATKINSON, H.M.I.M.
J. BARNES.
H. H. BOLTON, Jun.
J. CRANKSHAW.
S. GARSIDE.
G. C. GREENWELL, Jun., F.G.S.
G. B. HARRISON, H.M.I.M.
W. F. HOLROYD.
C. R. LINDSEY, B.Sc.
D. W. F. MATTHEWS, H.M.I.M.
G. H. PEACE, M.Inst.C.E.
T. SCOWCROFT.

Hon. Auditors:

G. H. HOLLINGWORTH, F.G.S. | H. A. WOODWARD.

APPENDIX TO THE REPORT.

PRESENTATIONS TO THE LIBRARY, 1895-6.

Barnsley.—Midland Institute of Mining, Civil, and Mechanical Engineers. Proceedings. Included in the Transactions of the Federated Institution of Mining Engineers. *From the Institution.*

Belfast.—Natural History and Philosophical Society. Report and Proceedings for Session 1894-5. *From the Society.*

Bristol.—Naturalists' Society. Proceedings. Part 1, Vol. VIII. *From the Society.*

Camborne.—Mining Association and Institute of Cornwall. Transactions. Part 2, Vol. IV. *From the Association.*

Cambridge.—Museum. 29th Annual Report Museums and Lecture Rooms' Syndicate for 1895, also Report of Comparative Geology, 1894-5. *From the Woodwardian Museum.*

Cardiff.—Natural History Society. Report and Transactions. Parts 1 and 2, Vol. XXVI. *From the Society.*

Cardiff.—Naturalists' Society. Part 2, Vol. XXVII. *From the Society.*

Chester.—Society of Natural Science and Literature. 25th Annual Report. *From the Society.*

Chesterfield and Midland Counties Institute of Engineers.—Transactions. Included in the Transactions of the Federated Institution of Mining Engineers. *From the Institution.*

Cornwall.—Royal Geological Society. Transactions. Part 1, Vol. XII. *From the Society.*

Dublin.—Royal Dublin Society. Journal. Vol. XVIII. Transactions. Parts 5-12, Vol. V.; Part 1, Vol. VI. Proceedings Parts 3 and 4, Vol. VIII. *From the Society.*

Edinburgh.—Geological Society. Transactions. Part 2, Vol. VII. *From the Society.*

Edinburgh.—Royal Physical Society. Proceedings. Vol. CXXIV. *From the Society.*

Glasgow.—Natural History Society. Parts 1-2, Vol. IV. *From the Society.*

Hamilton.—Mining Institute of Scotland. Transactions. Included in the Transactions of the Federated Institution of Mining Engineers. *From the Institution.*

Leeds.—Yorkshire Naturalists' Society. Transactions. Vol. XIX. *From the Society.*

Leicester.—Literary and Philosophical Society. Transactions. Parts 2, 3, 4, 5, Vol. IV., New Series. *From the Society.*

Liverpool.—Geological Association. Journal. Vol. XV. *From the Association.*

Liverpool.—Geological Society. Proceedings. Parts 3, 4, Vol. VII. *From the Society.*

London.—Royal Society. Proceedings. Parts 351, 352, Vol. LVIII.; Parts 353, 354, 355, 356, 357, 358, Vol. LIX.; and Parts 359, 360, 361, Vol. LX. *From the Society.*

London.—Institution of Mechanical Engineers. Proceedings. No. 3, for 1895; and No. 1, for 1896. *From the Institution.*

London.—Geological Society. Quarterly Journal. No. 204, Vol. LI.; and Nos. 205, 206, 207, Vol. LII., also Abstract of the Society's Proceedings, No. 648. *From the Society.*

London.—Geologists' Association. Proceedings. Parts 5, 6, 7, 8, 9. Vol. XIV. *From the Association.*

London.—Geological Magazine.—Nos. 377 and 378, Vol. II.; also Nos. 379, 380, 381, 382, 383, 384, 385, 386, 387, 388, Vol. III. *Purchased.*

London.—Iron and Steel Institute. Journal. Part 1. Vol. XLIII. *From the Institute.*

London.—Palæontographical Society. Proceedings. Part 2, Vol. XLIX. *From the Society.*

London.—Royal Institution of Great Britain. Proceedings. Part 3, Vol. XIV. *From the Institution.*

Manchester.—Literary and Philosophical Society. Memoirs and Proceedings. Parts 1 and 2, Vol. X. *From the Society.*

Manchester.—Geographical Society. Journal. Nos. 9-12, Vol. X.; and 1, 2, 3, 4, 5. 7, 9, Vol. XI. *From the Society.*

Mirfield.—Yorkshire Geological and Polytechnic Society. Proceedings. Part 1, Vol. XIII. *From the Society.*

Manchester.—Field Naturalists' Society. Report and Proceedings for 1895. *From the Society.*

Manchester.—Owens College. Calendar for Session 1895-6. *From the College.*

Newcastle-upon-Tyne.—Federated Institution of Mining Engineers. Vols. V., VI., VII.; Part 3, Vol. IX.; Parts 1, 2, 3, Vol. X.; Parts 1-2, Vol. XI. *From the Institution.*

Newcastle-upon-Tyne.—North of England Institute of Mining and Mechanical Engineers. Transactions. Included in the Transactions of the Federated Institution of Mining Engineers; also Report of the Proceedings of the Flameless Explosives Committee, Part 3. *From the Institution.*

Rochdale.—Literary and Scientific Society. Proceedings. Vol. IV., 1893-5. *From the Society.*

Stoke-on-Trent.—North Staffordshire Institute of Mining and Mechanical Engineers. Proceedings. Included in the Transactions of the Federated Institution of Mining Engineers. *From the Institution.*

Stoke-on-Trent.—Transactions and Annual Report of the Naturalists' Field Club. Vol. XXX. *From the Club.*

Swansea.—South Wales Institute of Engineers. Proceedings. Parts 6, 7, 8, Vol. XIX.; Part 1, Vol. XX. *From the Institute.*

Truro.—Journal of Royal Institute of Cornwall. Part 2, Vol. XII.; Part 1, Vol. XIII. *From the Institute.*

Watford.—Natural History and Field Club. Transactions. Parts 6 and 7, Vol. VIII. Parts 1 and 2, Vol. IX. *From the Club.*

Wigan.—Science and Art of Mining. Nos. 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, Vol. VI., and Nos. 1, 2, 3, 4, Vol. VII.

Pamphlets and Reports.—English and Foreign.

Report on Minerals and Mining in New Zealand.

Report on the Nickel Deposits near Riddles, Oregon.

Bradford Free Libraries 25th Annual Report. *From the Committee.*

The Mitchell Library, Glasgow. 12th Annual Report. *From the Committee.*

Report on the Inspection of Mines in India for 1895. By James Grundy. *From the Author.*

Mineral Statistics of the Mines and Quarries for 1895. *Presented by Joseph S. Martin.*

Report of the Department of Mines of Western Australia for 1894.

Summer Meteorology, with Diagrams. By W. G. Black, F.R.C.S., Ed., &c. *From the Author.*

Tantallon Castle. The Story of the Castle and the Ship. By E. R. Pennell. *Presented by Messrs. Donald Currie & Co.*

India.

Calcutta.—Records of the Geological Survey of India. Part 4, Vol. XXVIII.; and Parts 1, 2, 3, Vol. XXIX. *From the Governor General in Council.*

Australia.

Adelaide.—Royal Society of South Australia. Transactions. Parts 2-3, Vol. XIX. *From the Society.*

Sydney.—The Australian Mining Standard: A Record of Mining, Financial, and Engineering Progress, Nos. 358-372, Vol. XI.; Nos. 373-400, Vol. XII., and Nos. 1-10, Vol. XIII. *From the Editor.*

Sydney.—Geological Survey of New South Wales: Department of Mines. Records, Part 4, Vol. IV.; Palæontology, No. 9; Annual Report Department of Mines and Agriculture, New South Wales for 1895. *From the Hon. the Minister of Mines.*

Canada.

Halifax, N.S.—Nova Scotian Institute of Science. Proceedings and Transactions. Part 4, Vol. VIII., and Part 1, Vol. IX. 2nd series. *From the Institute.*

Ottawa.—Canadian Mining Review. Nos. 10-12, Vol. XIV.; and Nos. 1-9, Vol. XV. *From the Editor.*

Ottawa.—Geological and Natural History Survey of Canada. Palæozoic Fossils. Part 1, Vol. II., also Maps. *From the Director of the Survey.*

Ottawa.—Journal of the General Mining Association of Quebec. No. 2 for 1894-5. *From the Association.*

St. John, New Brunswick.—Natural History Society of New Brunswick. Bulletin 13. *From the Society.*

Toronto.—Canadian Institute. Transactions. Part 2, Vol. IV. *From the Institute.*

U.S. AMERICA.

California.—Berkeley University of California. Bulletin of the Department of Geology, No. 11, Vol. I.

Cambridge.—Harvard College. Bulletin of the Museum of Comparative Zoology. Nos. 4, 5, 6, Vol. XXVII., and Nos. 1, 2, 3, 4, 5, 6, Vol. XXIX. *From Alex. Agassiz.*

Chicago.—Academy of Science. Bulletin 2, Vol. II. *From the Academy.*

Denver.—Colorado Scientific Society. Proceedings. Vol. V. *From the Society.*

Iowa.—Geological Survey of. Vol. IV. *From the Director of the Survey.*

Minneapolis.—The American Geologist. Nos. 5, 6, Vol. XVI.; Nos. 1-6, Vol. XVII., and Nos. 1-4, Vol. XVIII. *Purchased.*

New York.—American Institute of Mining Engineers. Transactions. Vol. XXV. *From the Institute.*

New York.—The American Museum of Natural History. Bulletin, Vol. VII.; also Annual Report for 1895. *From the Museum.*

Philadelphia.—Franklin Institute. Journal. No. 839, Vol. CXL.; Nos. 840, 841, 842, 843, 844, 845, 846, Vol. CXLI.; and Nos. 847, 848, 849, 850, Vol. CXLII. *From the Institute.*

Philadelphia.—Academy of Natural Sciences. Proceedings. Parts II. and III., 1895, and Part I., 1896. *From the Academy.*

Scranton, Pa.—The Colliery Engineer. Journal. Nos. 4-12, Vol. XVI.; and Nos. 1-3, Vol. XVII. *From the Editor.*

Washington.—Smithsonian Institute :—

U.S. Geological Survey of Mineral Resources of the U.S., 1893-94.

" " " Bulletins, Nos. 123-126, 127-134.

" " " 15th Annual Report, 1894-95. Part I.

" " " 15th Annual Report, 1894-95. Part 2.

" " " 15th Annual Report, 1894-95. Part 3.

" " " 15th Annual Report, 1894-95. Part 4.

" " " 16th Annual Report, 1895-96. Part 1.

Wisconsin.—Academy. Proceedings. Vol. X. *From the Academy.*

FOREIGN.

Berlin.—Gesellschaft für Erdkunde : Zeitschrift, Nos. 5 and 6, Vol. XXX.; Nos. 1, 2, 4, Vol. XXXI.; Verhandlungen, Nos. 8 and 9, Vol. XXII.; Nos. 1, 2, 3 4, 5, 7, Vol. XXIII. *From the Society.*

Berlin.—Zeitschrift der Deutschen Geologischen Gesellschaft. Heft 2, 3, 4 Vol. XLVII.; Heft 1, Vol. XLVIII. *From the Society.*

Bruxelles.—Annales Société Royal Malacologique de Belgique. Vol. XXVII.

Buenos Ayres.—Anales del Museo National de Buenos Ayres. Ser. 2. Tomo. IV.

Buenos Ayres, Direccion General de Estadistica, 1894.

Caen, Calvados, France.—Société Linnienne de Normandie. 4th Series, Vol. IX..

Dresden.—Sitzungsberichte des Naturwissenschaftlichen Gesselschaft Isis in Dresden. January to June, 1895. *From the Society.*

Halle, A.S.—Mittungen des Vereins fur Erdkunde, 1895. *From the Society.*

Lausanne (Suisse). — Société Vaudoise des Sciences Naturelles, Bulletin 118-119, Vol. XXXI.; and Bulletin 120, Vol. XXXII. *From the Society.*

Lille.—Société Géologique du Nord. Annales, Vol. XXII.

Mexico.—Sociedad Cientifica "Antonio Alzate." Memorias Y. Revista. Nos. 1-4, Vol. VIII., and 1-10, Vol. IX.

Mexico.—Institute Geologico de Mexico. Bulletin No. 3.

Naples.—Rendiconto dell Accademie Scienze Fisiche e Mathematiche. Nos. 8, 10, 12, Vol. 1, 3rd Series. *From the Academy.*

Paris.—Bulletin Société de Spéléogique. No. 1, 2, 3, 4, Vol I., and 1-7, Vol. II.

Roma.—Atte della Reale Accademia dei Lincei Rendiconti. Nos. 8-12, Vol. IV.; Nos. 1-12, Vol. V.; and Nos. 1-7, Vol. VI. Rendiconti Annual. *From the Academy.*

St. Petersburg.—Bulletin du Comite Geologique. Nos. 8 and 9, Vol. XII.; 1-9, Vol. XIII.; Nos. 1-9, Vol. XIV.; and 1 and 2, Vol. XV.; also Supplement to Vol. XIII.; also Memoires.

St. Petersburg.—Société Imperiale Mineralogique (Institute des Mines), 1895.

St. Petersburg.—Memoires L'Academie Imperiale des Sciences. Nos. 2-3-5, Vol XLII. *From the Academy.*

St. Petersburg.—Bulletin de L'Academie Imperiale des Sciences de St. Petersburg. V. Series, No. 1, Vol. VIII. *From the Academy.*

Stockholm.—Lefnadsteckningar oföer Kongl Svenska Vetenskaps Akademiens. Bond 2; Haft 2.

Wien.—Annalen K. K. Naturhistorischen Hof Museums. Nos. 1-2-3-4; Vol. X.

Societies with whom the Society Exchanges its Transactions and Institutions and Journals to whom a Copy is sent free.

I.—England.

London .....British Museum.
Geological Society, Burlington House, W.
Geological Survey, Jermyn Street, S.W.
Geologists' Association, University College, Gower Street, W.C.
Institute of Mechanical Engineers, Victoria Street, S.W.
Iron and Steel Institute, Victoria Mansions, S.W.
Royal Institution of Great Britain.
Royal Society, Burlington House, W.
Public Library, Kensington, High Street, W.

Manchester .....The Manchester Association of Engineers, 18, Hullard Street, Old Trafford.
Field Naturalists' Society, 16, Kennedy Street.
Free Library, King Street.
Literary and Philosophical Society.
Owens College.
Salford Royal Museum and Library.
Scientific Students' Association, 36, George Street.

Barnsley .....Midland Institute of Mining Engineers.

Birmingham ....Free Library and Museum.
South Staffordshire and East Worcestershire Institute of Mining Engineers, Colmore Chambers, 3, Newhall Street.

Bradford .....Public Free Library, Bradford, Yorkshire.

Bristol .....Naturalists' Society, Clifton.

Cambridge ..... Geological Museum, University.
University Library.

Chester .....Society of Natural Science.

Chesterfield .....Institution of Mining Engineers, 13, Cavendish Street.

Cornwall.....Royal Geological Society, Penzance.
Royal Institution. Truro.

Tuckingmill, Camborne .. } Mining Association and Institute of Cornwall.

Essex .....Essex Field Club, 8, Knighton Villas, Buckhurst Hill, Essex.

Exeter.....Albert Memorial Museum.

Falmouth .....Falmouth Naturalist Society, De Beauvoir House.

Halifax .....Geological and Polytechnic Society of Yorkshire.

Leeds .....Philosophical and Literary Society.
Yorkshire Naturalists' Union (W. D. Roebuck, Esq., Hon. Librarian, Sunny Bank, Leeds).

Leicester.....Literary and Philosophical Society.

Liverpool .....Free Library and Museum.
Geological Association, Free Library, William Brown Street.
Geological Society.
Science Students' Association, Royal Institution, Colquitt Street.

Newcastle-on-Tyne.North of England Institute of Mining and Mechanical Engineers.

Newcastle, Staffordshire .... } North Staffordshire Naturalists' Field Club (Rev. T. W. Daltry, M.A., F.G.S., Madeley Vicarage).

Norwich .....Geological Society, Museum.

Oxford .....Bodleian Library.
Radcliffe Library.

North Shields....Public Free Library

Southampton ....Hampshire Field Club, Hartley Institution.

Stoke-on-Trent ..North Staffordshire Institute of Mining and Mechanical Engineers.

Swansea .....South Wales Institute of Mining and Mechanical Engineers.

Warwick .....Natural History Society.

Watford, Herts...Hertfordshire Natural History Society and Field Club, the Public Library, Watford.

Wigan .....Free Library.
Mining School.

II.—Scotland.

Dundee .....Free Library and Museum.

Edinburgh .....Advocates' Library.
Geological Society.
Royal Society.
Royal Physical Society.

Glasgow .....Geological Society
Natural History Society.

Hamilton .....Mining Institute of Scotland.

III —Ireland.

Dublin .....Royal Dublin Society.
Royal Geological Society of Ireland.
Trinity College Library.

Belfast .....Natural History Society, the Museum.

IV.—Australia.

Melbourne .....Geological Society of Australasia, 17A, Queen Street.
Public Library of Victoria.

Sydney .....Free Public Library.
Royal Society of New South Wales, 37, Elizabeth Street.
Department of Mines.—The Honourable the Minister of Mines.

V.—Canada.

Hamilton .....Hamilton Association.

Ottawa .....Geological and Natural History Survey of Canada (A. R. C. Selwyn, F.G.S., Director, Museum, Sussex Street, Ottawa).
M'Gill College (Principal, Sir J. W. Dawson, F.G.S.)
Editor of Canadian Mining Review.

Toronto .....Canadian Institute.

Halifax, Nova Scotia ..... } Nova Scotian Institute of Natural Science.

VI.—India.

Calcutta .....Geological Survey of India

VII.—United States.

Boston, U.S. ....Free Library.

Chapel Hill, North Carolina, U.S. } The Elisha Mitchell Scientific Society.

Columbus, U.S. ..Ohio, Geological Survey of (Professor Edward Orton, State Geologist).

Denver .....Colorado Scientific Society, Denver, Colorado.

Indiana, U.S.....Department of Geology and Natural History.

Indianopolis, U.S...Professor John Collett, State Geologist.

Newhaven, U.S...Professor O. C. Marsh, F.G.S.

New York, U.S...American Institute of Mining Engineers (R. W. Raymond, Box 223, New York City).

New York .....American Museum of Natural History, Central Park.

Philadelphia, U.S...Academy of Natural Sciences.
Franklin Institute.
Pennsylvania Geological Survey.
American Philosophical Society, 104, S. Fifth Street.

Shenandoah, Pa...Editor of the Colliery Engineer.

Washington, U.S...Department of the Interior. U.S. Geological Survey.
Smithsonian Institution.

Wyoming, U.S...Historical and Geological Society.

VIII.—Foreign Societies.

Berlin .....Deutsche Geologische Gesellschaft.
Gesellchaft fur Erdkunde. Zimmerstrasse, 90, Berlin, S.W., 12.

Brussels .....Société Royale Malacologique de Belgique.

Buenos Ayres ....Officiana Nacional de Commercie.

Christiania .....Royal University of Norway.

Dresden .....Naturwissenschaftliche Gesellschaft Isis.
Halle, A.S... ...Verein für Erdkunde.
Die Kaiserliche Leopold. Carol. Deutsche Akademie der Naturforscher.
Kazan, Russia....La Société des Naturalistes de l'Université de Kazan.
Kieff, Russia ....La Société des Naturalistes.
Lausanne (Suisse). Société Vaudoise des Sciences Naturelles.
Lõcse, Hungary ..Société Hongroise de Carpathes (Centrale in Leutschau).
Lille .....Société Geologique du Nord.
Naples .....Royal Academy of Sciences, Bibliothèque de l'Université de Naples.
Paris .....Annuaire Géologique Universel (Dr. Dagincourt, 15, Rue de Tournon).
Pisa .....Società Toscana di Scienze Naturali, Museo di Storia-Naturale.
Rio de Janeiro....Museo Nacional.
Rome .....Reale Academia dei Lincei.
St. Petersburg....Académie Impériale des Sciences.
Institut des Mines. Comité Géologique.
Turin .....Académie Royale des Sciences.

IX.—Scientific Journals, &c.

Iron and Coal Trades Review, 342, Strand, W.C.
Geological Record, W. Topley, F.G.S., Museum, Jermyn Street, London, S.W.
Mining Journal, Fleet Street, London.
Colliery Guardian, 49, Essex Street, Strand, London.
Science and Art of Mining, 27, Wallgate, Wigan.

PAST PRESIDENTS OF THE SOCIETY.

Year of Election.	
1838-9-40	Egerton, The Rt. Hon. Francis, M.P.
1841-2-3, 49-50-1	Heywood, James, F.R.S., F.G.S.
1843-4-5, 55-6-7	Egerton, Sir Philip de Malpas Grey, Bart., M.P.
1845-6-7	Moseley, Sir Oswald, Bart.
1847-8-9	Thicknesse, Ralph, M.P., Wigan.
1851-2-3	Black, James, M.D., F.G.S.
1853-4-5	Ormerod, G. W., M.A., F.G.S.
1857-8-9, 65-6-7	Binney, E. W., F.R.S., F.G.S.
1859-60-1	Kay-Shuttleworth, Sir, J.P., Bart., M.P.
1861-3, 77-8, 87-8	Dickinson, Joseph, F.G.S.
1863-4-5	Knowles, Andrew.
1867-8-9, 84-5	Greenwell, G. C., F.G.S., M.Inst.C.E.
1869-70-1, 82-3	Aitken, John, F.G.S.
1871-2-3, 88-9	Knowles, John, M.Inst.C.E., J.P.
1873-4	Knowles, Thomas, M.P.
1874-5, 6-7, 86-7	Dawkins, Professor W. Boyd, F.R.S., F.G.S.
1875-6	Smith, R. Clifford, F.G.S.
1878-9	Forbes, John Edward, F.G.S.
1879-80	Lindsay, Lord, F.R.S.
1880-1	Kay-Shuttleworth, Sir Ughtred J., Bart.
1881-2	Gilroy, George, M.Inst.C.E.
1883-4	Pilkington, Edward, J.P.
1885-6	Ormerod, Henry Mere, F.G.S.
1889-90	Hall, Henry, H.M.I.M.
1890-91	Burrows, John S., F.G.S.
1891-92	Tonge, James, F.G.S., Assoc.M.Inst.C.E.
1892-93	Peace, Maskell William, F.G.S.
1893-94	Saint, William, H.M.I.M.
1894-95	Watts, William, F.G.S.
1895-96	Winstanley, Robert, C.E.

LIST OF MEMBERS.

OCTOBER, 1896.

The Names of Honorary Members are printed in *Italics*.

* Members who have compounded for the Annual Subscription.

Year of Election.	
1874	*Agassiz, Alexander*, Cambridge, Massachussetts, U.S.A.
1884	Ainsworth, John, Colliery Offices, Walkden, Bolton.
1884	Aldred, James, Radcliffe.
1879	Arrandale, John Thomas, The Grange, Coppull, near Chorley.
1893	Ashworth, John, C.E., 8, King Street, Manchester.
1878	Ashworth, Thomas, 42, Deansgate, Manchester.
1877	Atherton, James, 13, Mawdsley Street, Bolton.
1895	Atherton, H. Stanley, Land and Mine Surveyor, 13, Mawdsley Street, Bolton.
1878	Atkinson, W. N., H.M. Inspector of Mines, Barlaston, Stoke-on-Trent. *Member of Council.*
1881	Aubrey, Richard Charles, 61, Bath Street, Southport.
1893	Bancroft, Robert Ed., 8, St. James's Square, Manchester.
1894	Banks, William, Electrician, Bolton.
1894	Barlow, Sam. C., Rock Cottage, Roman Road, Tiviot Dale, Stockport.
1895	Barnes, J., 1, Trafalgar Street, Lower Broughton. *Member of Council.*
1875	Barrett, W. S., New Hall, 41, Old Hall Street, Liverpool.
1880	Barton, Richard.
1889	Beck, William, Ellerbeck Collieries, near Chorley, Lancashire.
1891	*Bell, Thomas*, J.P., Valley Road, Scarborough.
1881	Black, W. G., F.R.C.S. Ed., F.G.S. Ed., 2, George's Square, Edinburgh.
1889	Bolton, Edgar O., Burnley Collieries, Burnley.
1867	Bolton, H. H., Newchurch, near Manchester.

Year of Election.	
1880	Bolton, H. H., jun., The Collieries, Accrington. *Member of Council.*
1887	Boole, George, Rainford Colliery, near St. Helens.
1894	Borrows, William, Engineer, Providence Foundry, St. Helens.
1878	Bradford, The Right Hon. the Earl of, Bradford Estate Office, Bolton (G. R. Carter, Esq., Agent).
1894	Bradshaw, Edward, Great Lever Collieries, Bolton.
1886	Bramall, Henry, M.Inst.C.E., Shade House, Pendlebury, Manchester.
1878	Bramall, Ernest E., Pendlebury Collieries, near Manchester.
1895	Brierley, Brandon Telford, C.E., Architect and Surveyor, Manchester.
1878	Brocklehurst, Thomas, Rumworth Colliery, Dean, Bolton.
1877	*Broeck, Ernest Van den*, 39, Place de l'Industrie, Brussels.
1877	*Brongniart, Charles*, F.E.S., 9, Rue Linné, Paris.
1881	Bryham, William, Douglas Bank Colliery, Wigan.
1878	Burrows, John S., F.G.S., Green Hall, Atherton, near Manchester. *Past-President.*
1882	Caldwell, George, Moss Hall Collieries, Wigan.
1884	Campbell, H. H., Surveyor, Hardshaw Street, St. Helens.
1887	Campbell, W. M., Sutton Heath Collieries, St. Helens.
1881	Clark, Christopher F., Park Lane Collieries, Wigan.
1882	Clark, George, Mining Engineer, Newton-le-Willows.
1894	Clark, Robert, 42, Deansgate, Manchester.
1889	Clay, Richard, Dukinfield Coal Company, Dukinfield.
1886	Clifford, William, 610, Lewis Block, Pittsburg, Pa., U.S.A.
1882	Cockson, Charles, King Street, Wigan.
1894	Cole, Robert H., Endon, Stoke-on-Trent.
1895	Coope, Samuel, Land and Mine Surveyor, Farnworth, Bolton.
1878	Cowburn, Henry, 253, West Leigh Lane, West Leigh, near Manchester.
1883	Crankshaw, Joseph, Montcliffe Colliery, Horwich. *Member of Council.*
1879	Crawford and Balcarres, The Right Hon. the Earl of, Haigh Hall, Wigan. *Past-President.*

Year of Election.	
1862	Cross, John, 77, King Street, Manchester.
1869	Dawkins, Professor W. Boyd, M.A., F.R.S., F.G.S., F.S.A., The Owens College, Manchester. *Past-President.*
1890	Dean, John, Wigan Coal and Iron Co., Limited, Wigan.
1877	*De Rance, C.E.*, F.G.S., Stoke Road, Shelton, Stoke-on-Trent, Stafford.
1856	Dickinson, Joseph, F.G.S., South Bank, Pendleton. *Past-President.*
1889	Dobbs, Joseph, Coolbawn, Castlecomer, Co. Kilkenny.
1884	Elce, George, Altham Colliery, Whalley Road, Accrington.
1878	Ellesmere, The Right Hon. the Earl of, Worsley.
1895	Ellis, Thomas Ratcliffe, Solicitor, King Street, Wigan.
1894	Evans, Robert, Mining Engineer, Royton, Oldham.
1880	Fairclough, William, Leigh, near Manchester.
1891	Fallows, William, Arbury Road, Nuneaton.
1891	Finch, John, Hampstead Colliery, Great Barr, Birmingham.
1891	Fletcher, Arthur, Outwood Collieries, Radcliffe.
1868	Fletcher, Thomas, Haulgh, Bolton.
1889	Foster, John W., 24, Silksworth Terrace, New Silksworth, Sunderland.
1873	Garforth, W. E., F.G.S., Halesfield, Normanton.
1893	Garside, Edward, B.Sc., 6, Chester Square, Ashton-under-Lyne.
1884	Garside, Samson, Denton and Haughton Collieries, Denton. *Member of Council.*
1889	Gascoyne, Rowland, Brackburn Collieries, Broxburg, near Johannesburg, South African Republic.
1874	*Geikie, Sir Archibald*, D.Sc., LL.D., F.R.S., Geological Survey, Jermyn Street, London, S.W.
1892	Gerrard, John, H.M. Inspector of Mines, Worsley. *Vice-President.*
1882	Glover, B. B., 41A, Victoria Buildings, Manchester.

Year of Election.	
1892	Grant, Frederick John, Bank Field, Burnley.
1890	Green, John, Ty'n Twll Colliery, near Mold, Flintshire.
1878	Greener, W. J., Pemberton Colliery, Wigan.
1882	Greenhalgh, Robert, Engineer, Atherton, near Manchester.
1883	Greensmith, T., Topcliffe House, Tingley, near Wakefield.
1863	Greenwell, G. C., F.G.S., M.I.C.E., Elm Tree Lodge, Duffield, Derby. *Past-President.*
1874	Greenwell, G. C., jun., F.G.S., Poynton, near Stockport. *Member of Council.*
1879	Greenwood, John, 63, Albert Road, Stockport.
1892	Gregson, G. Ernest, 11, Chapel Street, Preston.
1890	Gresley, W. S., F.G.S., P.O. Box 437, Erie, Pennsylvania, U.S.A.
1877	Grundy, H. T., Colliery Surveyor, Radcliffe.
1888	Grundy, James, H.M. Inspector of Mines, 27, Chowringhee Road, Calcutta, India.
1883	Hall, Jonathan, Clifton Hall Colliery, Clifton, Manchester.
1881	Hall, Henry, H.M. Inspector of Mines, Rainhill, Prescot. *Past-President.*
1887	Hallas, George H., Wigan and Whiston Coal Company, Limited, Prescot.
1892	Halliwell, James, Duxbury Park Colliery, Chorley, Lancashire.
1877	Handsley, Robert, Burnley Colliery Offices, Burnley.
1894	Harrison, George B., Inspector of Mines, 278, Brooklands Terrace, Worsley Road, Swinton, Manchester. *Member of Council.*
1892	*Haworth, Denis, Beech House, Blackburn Road, Accrington.
1894	Hayward, John, Ladyshore Colliery, Little Lever, Bolton.
1893	Heyes, William A., Electrician, 5, Dawson Street, Bolton.
1838	*Heywood, James, F.R.S., F.G.S., 36, Kensington Palace Gardens, London, W. *Past-President.*
1889	Higson, Charles H., The Park Collieries, Wigan.

Year of Election.	
1876	Higson, John, F.G.S., 18, Booth Street, Manchester.
1881	Hilton, James, 67, Hawkshead Street, Southport.
1892	Holden, Arthur T., Solicitor, 20, Mawdsley Street, Bolton.
1877	Holding, William, Cossall Colliery, near Nottingham.
1878	Hollingworth, George H., F.G.S., 12, King Street, Manchester. *Hon. Auditor.*
1895	Holroyd, W. F., River Cottage, Lower Broughton. *Member of Council.*
1893	Horrobin, Thomas, 334, Hill View, Breightmet, near Bolton.
1884	Howat, Andrew.
1884	Hughes, Owen, Limehurst, Ashton-under-Lyne.
1874	*Hull, Professor Edward*, M.A., F.R.S., 20, Arundel Gardens, Notting Hill, London, W.
1894	Hutchinson, John William, Bamfurlong Collieries, Wigan.
1889	Iles, John, 76, Church Street, South Shore, Blackpool.
1887	Jackson, Andrew, Manager, Collins Green and Bold Collieries, Newton-le-Willows.
1878	Jackson, Charles G., Anderton Hall, near Chorley.
1887	James, J. Stanley, Caswell Bay, near Swansea.
1883	Jobling Albert, Spring Wood House, Burnley.
1883	Jobling, Henry, Spring Wood House, Burnley.
1884	Jobling, John, Barcroft, Cliviger, Burnley.
1890	Johnson, Alfred E., Abram Colliery, Wigan.
1882	Johnson, William, Abram Colliery, Wigan.
1894	Kelsall, James E., High Bank, Tonge, Bolton.
1893	Kendrick, James P., 8, St. James's Square, Manchester.
1879	*Kinahan, G. H.*, M.R.I.A., Woodlands, Fairview, Co. Dublin.
1889	Knowles, James. Pearson, Knowles, & Co., Wigan.
1889	Knowles, John, Brynn Mount, Westwood, Lower Ince, Wigan.
1887	*Knowles, Lees, M.A., LL.M., M.P., Westwood, Pendlebury.

Year of Election.	
1886	Knowles, Robert, Ednaston Lodge, near Derby.
1893	Laithwaite, V. W., Post Office Chambers, Bradshawgate, Bolton.
1890	Law, Illingworth, Waterfoot, near Manchester.
1884	Leech, A. H., Brinsop Hall Colliery, Wigan.
1894	Lindsey, Charles R., B.Sc., Chemical Manufacturer, 509, Edge Lane, Droylsden, Manchester. *Member of Council.*
1862	Livesey, Clegg, Bradford Colliery, Manchester. *Hon. Treasurer.*
1877	Livesey, Thomas, Bradford Colliery, Manchester.
1896	Lomax, Charles, J., C.E., 19, Grosvenor Chambers, Manchester.
1877	Lord, James, Hill House, Rochdale.
1891	Marshall, Herbert S., The Larches, Wigan.
1893	Matthews, E. L., Mechanical Engineer, &c., Imperial Iron Works, West Gorton, Manchester.
1892	Matthews, D. H. F., H.M. Inspector of Mines, Hoole, Chester. *Member of Council.*
1896	Matthews, Thomas, Artesian Engineer, West Gorton, Manchester.
1881	Mc.Alpine, G. W., Parkside, Accrington.
1890	McGeevor, James, Garswood Hall Colliery, Wigan.
1873	*Martin, Joseph S.*, H.M. Inspector of Mines, Durdham Park, Clifton, Bristol.
1885	Mawson, Robert Bryham, Sovereign Colliery, Westleigh, Leigh, near Manchester.
1890	Mercier, Maunsell, 5, Deansgate, Manchester.
1892	Miller, Arthur, Broad Oak, Hurst, Ashton-under-Lyne.
1892	Millington, W. W., Hardman House, Hollinwood, Oldham.
1892	Mills, David, Bradford Street, Farnworth.
1895	Mitton, A. Dury, Old Road, Eccles.
1876	Moore, Alfred, C.E., Queen's Chambers, No. 2, Ridgefield, Manchester.
1892	Morris, Moses, Swan Lane, Hindley, Wigan.

Year of Election.	
1895	Mort, Arthur, 345, Ashton New Road, Clayton, Manchester.
1874	*Morton, G. H.*, F.G.S., 209, Edge Lane, Liverpool.
1888	Munro, Donald, Fairfield, near Manchester.
1878	Nall, Simon, Newbold, Rochdale.
1888	Oliver, Samuel A., King Street, Wigan.
1891	Orchard, Albert J. A., Atherton Colliery, Atherton, near Manchester.
1838	*Ormerod, H. M.*, F.G.S., 5, Clarence Street, Manchester. *Past-President.*
1876	Peace, George, Monton Grange, Eccles. *Vice-President.*
1863	Peace, George Henry, M.Inst.C.E., Monton Grange, Eccles. *Member of Council.*
1877	Pickup, Peter Wright, Rishton, near Blackburn.
1884	Piggott, I., Carlton Villa, Lathom, near Ormskirk.
1873	Pilkington, Alfred, Clifton Collieries, near Manchester.
1879	Pilkington, Charles, The Headlands, Prestwich, Manchester.
1873	Pilkington, Edward, J.P., Clifton Collieries, near Manchester. *Past-President.*
1877	Place, W. H., Hoddleston Collieries, Darwen.
1887	Platt, Samuel Sydney, Assoc.M.Inst.C.E., F.G.S., 14, King Street South, Rochdale. *Vice-President.*
1891	Prestwich, Joseph, Irwell Park, Eccles.
1895	Purdy, Richard, Moston Colliery, Newton Heath, Manchester.
1860	Ridyard, John, F.G.S., Hilton Bank, Little Hulton, Bolton. *Vice-President.*
1893	Rigby, John, Highfield, Winsford, Cheshire.
1889	Robinson, John, Haydock Collieries, St. Helens.
1890	Robson, Thomas, Wigan and Whiston Colliery Co., Prescot.
1892	Roscoe, George, Peel Hall Collieries, Little Hulton, Bolton.

Year of Election.	
1895	Rothwell, Samuel, Silverwell Street, Bolton.
1895	Ryans, Joseph, Colliery Manager, Arigna Mines, Carrick-on-Shanon.
1887	Saint, William, H.M. Inspector of Mines, Kersal Bank, Higher Broughton, Manchester. *Past-President. Hon. Secretary.*
1888	Scarborough, George Edward, Colliery Manager, New Town and Meadows Collieries, Wigan.
1887	Scott, Frederick W., Atlas Works, Reddish, near Stockport.
1889	Scott, William B., 133, Manchester Old Road, Middleton.
1891	Scowcroft, Thomas, Redthorpe, Tonge, Bolton. *Member of Council.*
1882	Settle, Joel, The Hill, Alsagar, Stoke-on-Trent.
1878	Settle, Miles, Snow Hill, Darcy Lever, near Bolton.
1889	Settle, William, Snow Hill, Darcy Lever, near Bolton.
1884	Shaw, David, Norbury Moor, near Stockport.
1887	Shuttleworth, Sir Ughtred J. Kay, Bart., Gawthorpe Hall, Burnley. *Past-President.*
1884	*Simpson, W. W., Winkley, near Whalley, Blackburn.
1894	Slee, John, Engineer, Earlestown.
1864	*Smethurst, William, F.G.S.
1893	Smith, Henry.
1881	Smith, John, Bickershaw Collieries, West Leigh, near Manchester.
1873	*Smith, R. Clifford, F.G.S., Ashford Hall, Bakewell. *Past-President.*
1888	Smith, Sydney Arthur, 1, Princess Street, Albert Square, Manchester.
1881	Southworth, Thomas, Hindley Green Collieries, Wigan.
1886	Speakman, Harry, Bedford Collieries, Leigh, Lancashire.
1881	Squire, J. B., A.Inst.C.E., 297, Clapham Road, London, S.W.
1890	Stafford, Thomas, 1, Lea Road, Heaton Chapel, Stockport.
	Stechert, G. E., 30, Wellington Street, Strand, London, W.C.

Year of Election.	
1880	Stirrup, Mark, F.G.S., High Thorn, Stamford Road, Bowdon. *President.*
1882	Stopford, T. R., Ashton's Green Collieries, St. Helens, Lancashire.
1891	Sutcliffe, Richard, Horbury, near Wakefield.
1889	Taylor, William, 6, Bull Hill, Darwen.
1892	Thom, John, Canal Works, Patricroft.
1893	Thompson, F. W., 5, Wood Street, Bolton.
1892	Thompson, James, Westhoughton, Bolton.
1894	Thompson, John G., Mining Engineer, Bamfurlong, Wigan.
1893	Thompson, Peter, 40, Hardman Street, Hollinwood, Oldham.
1893	Timmins, Arthur, A.M.I.C.E., F.G.S., Bridgewater Foundry, Runcorn.
1884	Toman, Daniel. Messrs. Blundell, Pemberton Colliery, Wigan.
1891	Tonge, Alfred J., Hulton Colliery, near Bolton.
1873	Tonge, James, F.G.S., Assoc.M.Inst.C.E., Albany Chambers, Mawdsley Street, Bolton. *Past-President. Hon. Secretary.*
1886	*Trafford, Sir Humphrey Francis de, Bart., Trafford Park, Manchester.
1895	Travers, T. W., Mining Engineer, Church Street, Leigh, Lancashire.
1892	Turner, William, Wigan Junction Colliery, Abram, near Wigan.
1876	Unsworth, John, Scot Lane Collieries, Wigan.
1887	Walkden, Richard, Colliery Manager, 26, Watery Lane Terrace, Springvale, Darwen.
1882	Walker, T. A., Pagefield Iron Works, Wigan.
1882	Wall, Henry, Rowbottom Square, Wallgate, Wigan.
1893	Wallwork, Jesse, Shakerley Collieries, Tyldesley, near Manchester.

Year of Election.	
1888	*Walmesley, Oswald, 2, Stone Buildings, Lincoln's Inn, London.
1879	Walshaw, John, Astley and Tyldesley Collieries, Tyldesley.
1892	Warburton, Thomas, 10, Bolton Road, Moses Gate, Bolton.
1892	Ward, Alexander Haustonne, Ranigunj, Bengal, India.
1885	Ward, Thomas, J.P., F.G.S., Brookfield House, Northwich.
1880	Watts, William, F.G.S., Piethorne, Rochdale. *Past-President.*
1878	Wells, Samuel B., Mining Engineer, Calcutta.
1877	West, T. E., Union Street, Oldham.
1890	*Whitaker, William*, B.A., F.R.S., F.G.S., Freda, Camden Road, Croydon.
1891	Whitehead, J. J., Duxbury Park Colliery, Chorley, Lancashire.
1867	Wild, George, Albert Street, Bardsley, Ashton-under-Lyne.
1895	Wilkinson, Fred, F.G.S., Director, Technical School, Bolton.
1880	Williams, Sir E. Leader, M.Inst.C.E., Manchester Ship Canal Company, King Street, Manchester.
1876	Winstanley, Robert, C.E., 42, Deansgate, Manchester. *Past-President.*
1886	*Wood, Guy, 71, King Street, Manchester.
1876	Woodward, H. A., Oakwood, Clifton, near Manchester. *Hon. Auditor.*
1895	Wordsworth, T. H., New Moss Colliery, Audenshaw, near Manchester.

Members are requested to communicate to the Hon. Secretaries all changes of address, also any corrections or omissions in the list.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART II. VOL. XXV. SESSION 1896-97.

The ORDINARY MEETING of the Members was held on Tuesday, November 10th, 1896, at the Society's Rooms, Queen's Chambers, John Dalton Street.

The President: Mr. MARK STIRRUP, F.G.S., in the Chair.

THE INTERNATIONAL CONGRESS OF GEOLOGISTS.

Before proceeding with the delivery of his address,

The PRESIDENT called the attention of members to a circular which had been issued with reference to the forthcoming International Geological Congress at St. Petersburg towards the end of August, 1897, and the facilities offered for extended travel to intending visitors to the Russian Capital. Owing to the liberality of his Imperial Majesty the Emperor, arrangements are being made for a visit to the Ural Mountains, the Caucasus, the Crimea, Southern Russia, Moscow, and Finland, gratuitous passes on the State-railways being accorded to those geologists who have announced their desire to take part in the Congress.

DONATIONS TO THE LIBRARY.

The PRESIDENT also stated that Mr. William Whitaker, F.R.S, an old friend and Honorary Member of the Society, from whom they had received previous gifts, had sent a valuable contribution of books for the library. They consisted, amongst other things, of a series of Memoirs of the Indian Geological Survey, Reports on New Zealand geology, the second edition of William Phillips' Geology, and numerous pamphlets on European, American, and British geology. It would be known to some of the members, the President said, that Mr. Whitaker, who was an old and valued member of the staff of the Geological Survey, and lived at Southampton, had lately resigned his position after 40 years' service. They had long experienced his goodwill in the Manchester Geological Society, although his field of labour had been principally in the South of England.

Professor BOYD DAWKINS moved that the best thanks of the Society be given to Mr. Whitaker for his liberal donation.

The motion was seconded by Mr. TONGE, and carried unanimously.

The PRESIDENT delivered the following address:—

THE EARLY HISTORY OF THE MANCHESTER GEOLOGICAL SOCIETY, WITH SOME REMARKS ON SPECULATIVE GEOLOGY.

By the President, MARK STIRRUP, F.G.S.

PART I.

The Early History of the Society.

Long custom exacts that your President should inaugurate his year of office by delivering an address. To choose a subject likely to interest the entire body of members is, however, not so easy a matter; a difficulty, I have no doubt, that has presented itself to many of my predecessors in the Presidential chair.

Those members who are more connected with the practical application of the science of geology—I refer to the mining and mechanical engineers—will, I feel sure, forgive me if I refrain from touching upon subjects with which they are more intimately acquainted than I can possibly be.

The time at my disposal, since my election to the position in which you have been pleased to place me, has not permitted me to prepare a special geological theme for your consideration, such as you might naturally expect, for which reason my address may present a less scientific character, but I hope it will not be uninteresting on that account.

Assuming that, as members, you are all concerned in the welfare and prosperity of the Society, and that probably many of you, especially the younger or newer members, are unacquainted with the circumstances of its foundation and its early history, I thought it would be useful and suggestive

if I brought before you some of the facts and incidents connected therewith.

The materials for this purpose I have been able to glean from a perusal of the first minute books of the Council, which have fortunately been preserved.

The Society, as you are all aware, dates its existence from the year 1838, nearly 60 years ago, a period almost concurrent with that of the reign of Her Majesty Queen Victoria. Anyone acquainted with the Manchester of that day will be able to realize the great changes that have been brought about, even within so comparatively short a period, by the increase of the population and the extension of the trade of the district. One of the effects of these changed conditions,—the migration to the suburbs of the merchants and more prosperous inhabitants,—is visible in consulting one of the early lists of the Members of the Society, many of whom belonged to the professional class and whose residences were at that time situated in a few of the more central streets of the town,—streets which are now wholly given up to commerce.

Before reviewing the early history of the Society, it will be well perhaps to cast a glance at some of the circumstances of the time, and the influences at work which I conceive led up to its establishment.

The beginning of the present century is remarkable for the great advances made in the various sciences, such as physics, chemistry, geology, and the several branches of natural history, sciences of experiment and observation which have been not only studied with a view to their practical application to industrial enterprise, but also largely for their value in the training of the mental faculties.

It is not my province to dilate upon the share which each of these respective sciences may have had upon modern progress, but simply and shortly endeavour to show the

probable connection with the birth of our Society of this awakening of the nation to the appreciation of the value of scientific research.

Confining myself to the modern history of geology, we find the present century ushered in with the promulgation and dissemination of wider and clearer views, on many points relating to the physical history of the earth and of creation, than had been hitherto current, even among men of culture.

This fact was due doubtless to a general advance in scientific knowledge and in great part to the appearance of such works as "Hutton's Theory of the Earth," published in 1795, and Professor Playfair's Illustrations thereof, in 1802, books which excited much discussion.

These works were rapidly succeeded by the labours of Buckland, Conybeare, Phillips, William Smith (the founder of Stratigraphical Geology), Sedgwick, De la Beche, Murchison, Lyell, and others; publications which placed the science of geology in the front rank of intellectual studies.

I might here remark the curious coincidence of the foundation year of the Society being synchronous with the publication of the first edition of "Lyell's Elements of Geology," which appeared in 1838, (Lyell's Principles of Geology dating from 1830,) and the completion of Roderick J. Murchison's great work on the Silurian System in the same year. In 1807 the Geological Society of London was founded, and in 1811 the first volume of its Transactions was published.

The activity thus shown in the prosecution of geological researches in connection with the many problems agitating men's minds as to the character and mode of action of the processes of Nature, both present and past, together with the spirit of enquiry evoked by the writings of such masters

of science as those already mentioned, had doubtless much influence in drawing public attention to the science of geology.

Perhaps one of the most potent factors in the foundation of provincial scientific societies has been the organization known as the "British Association for the Advancement of Science," whose first meeting was held in York in the year 1831, and in which our townsman, John Dalton, took a prominent part.

The main object of the Association, as you well know, was "to give a stronger impulse and a more systematic direction to scientific enquiry, and to promote the intercourse of those who cultivate science in different parts of Great Britain."

Manchester, whose townsmen have been always noted for their interest in literature, philosophy and science, could not long remain uninfluenced by the speculations and researches of the many able leaders in science that met together at these memorable gatherings. This, I take it, with other circumstances of the time, contributed to the foundation of the Manchester Geological Society.

It may be of interest here to note that the year of the foundation of our Society appears to have been the earliest attempt in Lancashire to promote the formation of a special organization for the cultivation of geology.

Not only has the Society this distinction of priority in the county, but it stands very near being the first in the whole of the North of England, the only possible claimant to that honour being the Yorkshire Geological and Polytechnic Society, whose institution antedates our own by one year only.

Even Edinburgh, the home of Hutton and Playfair, did not possess a Geological Society until 1834.

Having thus very briefly referred to some of the events

which preceded and probably influenced the establishment of our Society, I propose now to give some particulars of its birth and early years which will doubtless be of interest not only to the members, but to others outside our ranks.

After some preliminary consultations, the promoters of the Manchester Geological Society decided to call a public meeting, to which all those interested in the movement were invited to attend.

This meeting duly took place on the 15th October, 1838, at the York Hotel, King Street, Manchester, the site of which building is now occupied by the Manchester and County Bank.

The chair was occupied by Lord Francis Egerton, M.P., F.G.S. (afterwards created the First Earl of Ellesmere).

Among the gentlemen who took a more or less prominent part on that occasion were some of the more notable townsmen of that day, such as James Heywood, F.R.S.; William Langton, Dr. Fleming, Shakespear Phillips, William Fairbairn, the Engineer (afterwards made a Baronet), H. C. Campbell, Francis Looney, F.G.S.; Edmund Ashworth, Dr. Ainsworth, Richard Birley, S. E. Cottam, Eaton Hodgkinson, F.R.S.; Thomas Kirkham, Jun.; W. J. Wilson, Samuel Swire, James Meadows, and others.

The result of the meeting was the resolution to found a Society to be called the Manchester Geological Society (thus named in order to give it a location rather than a limitation of its sphere of operation).

A Provisional Council was appointed, among which appear the names of Sir Philip Malpas de Grey Egerton, F.G.S., who became a life member; Mark Philips, M.P.; E. W. Binney; Dr. Black; Matthew Dawes, F.G.S., of Bolton; G. S. Fereday Smith, F.G.S.; Paul Moon James, and others; Lord Francis Egerton being elected President.

Dr. Dalton was elected the first honorary member, while

his old friend Peter Clare, F.R.A.S., became an ordinary member of the Society.

To the list of members were soon added the names of other gentlemen of distinction who thus gave their approval of the objects that the Society had in view, viz.: Edward Stanley, Bishop of Norwich; Dr. John S. Newbold; George Ormerod, LL.D., F.R.S., &c.; G. Wareing Ormerod, M.A., F.G.S.; Henry Mere Ormerod, F.G.S.; Sir Benjamin Heywood, Bart.; Edward Loyd, Banker; Robert H. Greg, F.G.S.; W. Rathbone Greg; S. D. Darbishire; John Frederick Bateman, F.G.S.; Sir Oswald Mosley, Bart.

It will perhaps be of interest to recite the first two resolutions of this initiatory meeting, which may be taken to embody the views and aspirations of the founders. The first resolution runs thus: "That the importance of the mineral structure of the surrounding district, and the increasing interest which prevails at the present day in the progress of geology and in the general advancement of science, require the establishment of a Geological Society at Manchester, and that the Society be entitled 'The Manchester Geological Society.'"

The second resolution is to the following effect:—"That the objects of the Manchester Geological Society shall be to investigate the mineral structure and organic remains of the earth; to inquire into the statistics and machinery of mining, to collect books, sections, maps, models, and mining records, to publish the transactions of the Society with suitable illustrations, and to form a Museum to be open gratuitously to the public."

This latter resolution, as you will see, is framed in no narrow spirit of exclusiveness. The researches of the geologist and palæontologist, as well as the practical work of the miner and mining-engineer, are all included within its wide embrace.

The public spirit also which actuated the founders is visible in the enactment that the museum, which was proposed to be formed, should be open to the public gratuitously.

The Society having thus been successfully launched, it became the first business of the Council to find suitable premises for future meetings, a task not less difficult then than now.

The Council meetings were in the meantime held at either Mr. S. E. Cottam's Office, 28, Brazennose Street, or at Heywood's Bank, St. Ann's Street, where accommodation had been kindly offered.

Eventually the premises, 25, Faulkner Street, were rented for the use of the Society, the unused rooms being let to the Phrenological Society.*

The first general meeting of the Society was, by permission, held at the Royal Institution, Mosley Street, on the 17th January, 1839, in the room then occupied by the Choral Society. Lord Francis Egerton being unable to be present, the Chair was taken by James Heywood, F.R.S., who read a paper "On the Geology of the Irwell between Clifton and Manchester."

The Society being now fully constituted, gifts for the Museum, which formed so important a part of the Society's plans, began to come in.

The first donation was a collection of coal fossils from Wigan, which had been purchased by Charles Scarisbrick, Esq., and presented by him to the Society.

This gift was soon succeeded by numerous others from members and friends, among the most important of which may be named the valuable additions made from time to time by that steadfast and generous friend, as well as active

* Phrenology or the doctrines of Gall and Spurzheim being at that time very popular.

member, James Heywood, Esq., F.R.S., F.G.S., who is probably now the only surviving member of that band of gentlemen who were present at the meeting at the York Hotel, in October, 1838. Besides gifts of money to the Society and of books to the library, the museum was indebted to Mr. Heywood for the following donations :—

A suite of rocks and minerals from the Isle of Elba; a valuable collection of fossils from the Mountain Limestone, collected by Mr. Gilbertson, of Preston; an important series of about 4,500 specimens of fossils and minerals, collected by Mr. George Cumberland, of Bristol, a well-known geologist of the day; a collection of Tertiary fossils, with the table cases, from his house in Mosley Street.

It was also to Mr. Heywood, in conjunction with the late George Hadfield, of Manchester, at one time M.P. for Sheffield, that the fine specimen of an Ichthyosaurus, from the alum shale beds near Whitby, was secured in 1847, and which is now one of the treasures of the Manchester Museum, at Owens College.

Other valuable contributions came in from various sources, among which may be named those of the following gentlemen :—

Sir Philip Egerton, F.G.S., gave about 600 specimens of European rocks and fossil fishes from the Old Red Sandstone of Gamrie.

Lord Francis Egerton, a collection of fossil plants from the Worsley Collieries.

John Eddowes Bowman, F.G.S., one of the most earnest workers in the establishment of the Society, presented, in addition to a series of Lower Silurian fossils from the Berwyn Mountains, collected by himself, four specimens of the roots of the large carboniferous trees found at Dixon Fold during the cutting of the Bolton railway line, an account of which

discovery is contained in the first volume of the Society's Transactions, written by Mr. Bowman.

Mr. Samuel Gibson, a well-known geologist, of Hebden Bridge, to whom Phillips was indebted for many of the species of shells figured in his "Geology of Yorkshire," contributed a series of shells from the Coal Measures of Shedden Clough, Cliviger, and the neighbourhood.

The Marquis of Northampton sent a number of Tertiary fossils from Palermo.

Mr. William Peace, of Wigan, some valuable carboniferous fish remains from the Wigan coalfield.

Ralph Thicknesse, Esq., fossil coal plants from the Kirkless Colliery, near Wigan.

G. W. Buck, a flagstone containing footprints of Cheirotherium Hercules from the Stourton Quarries, Cheshire.

G. Fereday Smith, two slabs of fossil footprints from the Trias of Weston Point, Runcorn.

In 1851 a large and very valuable collection of carboniferous fossil plants, which had for some time been deposited in the Museum on loan by Mr. Matthew Dawes, of Bolton, was presented by him to the Society.

T. L. Gooch, the eminent railway engineer, sent coal plants and shells from the Summit Tunnel. This was one of several donations of like character made by him and other engineers in charge of the railway lines then being constructed in the neighbourhood of Manchester.

John Hawkshaw, F.G.S., engineer of the Bolton line, who was afterwards knighted, took an active part at that time in the Society's proceedings.

This list does not by any means include all the donations to the Society's Museum, but only some of the most prominent in the early years of the Society's existence.

After about a year's occupation of the premises in Faulkner Street, the Council accepted the offer of Mr. James Heywood of the use of part of his house at 52, Mosley Street, a tenancy which was only of short duration, owing to large additions to the Museum forcing the Society to seek increased accommodation elsewhere.

Early in 1842 negotiations were opened with the Council of the Royal Institution, which resulted in suitable rooms being placed at the disposal of the Society. These new quarters were entered upon in June, 1842, and great efforts were made by the Society to arrange their collections of fossils and minerals in time for the projected meeting of the British Association, which paid its first visit to the town in that year.

Sir Roderick Murchison, F.G.S., refers to these collections and the Society's work in laudatory terms on the occasion of his next visit to Manchester, at the British Association Meeting of 1861, he having been President of the Geological Section at both meetings.

In concluding his address of 1861, he says:—"I may assure the section that, as one of the original members of the Association, it gives me infinite satisfaction to return to my old friends in this great and thriving centre of our national industry. In common with many of our associates who come from a distance, well do I remember how cordially we were received here in the year 1842; and never can I forget how admirably we were presided over by a nobleman (Lord Francis Egerton) as distinguished by his ability and learning as he was beloved for his philanthropy and public spirit, and who had upon his right hand the illustrious Dalton.

"Lastly let me say that we of the Geological Section, who are gathered together from remote parts, have solid grounds for satisfaction in being greeted here by so many

good and active brother workmen of the Geological Society of Manchester, who have done such honour to their town, not only by their establishment of a rich and instructive Museum, in which many of the subjects we are met to discuss are thoroughly illustrated, but who have also by their publications contributed much to advance our science."

In addition to the valuable papers published in the Transactions of the Society, which are evidence of the activity of the members, several important public movements were aided by the influence which the Society was able to concentrate upon them.

It was chiefly due to the exertions of the Society in memorializing the Lords Commissioners of Her Majesty's Treasury, through Lord Francis Egerton, M.P., in 1840, that the districts of the Lancashire and adjoining coalfields were re-surveyed by the Board of Ordnance on the larger scale of six inches to a mile.

In the second annual report of the Society, in October, 1840, under the Presidency of Lord Francis Egerton, it is stated "that the Master General of the Board of Ordnance has been directed to duly consider any observations the Society may have to offer in regard to the objects to be included in the survey, and the purposes to which it may be desirable to render it subservient."

Of the value and superiority of the six inch over the one inch scale map then in use, for the adequate display of the topographical features and geological details of the country it is needless to speak.

The Society also joined in the petition, in 1843, to the House of Commons in favour of the Bill of George William Wood, M.P., F.G.S., an Associate of the Society, in favour of the exemption of the land and buildings occupied by Scientific and Literary Societies from County, Borough,

Poor and other Local Rates, an exemption which is now the law of the land.

Another laudable work in which the Society engaged was the attempt to diffuse among the working colliers of the district a knowledge of the nature of the Davy lamp and of the explosive gases met with in coal mines, with a view to the prevention of the great loss of life by explosions, then much more frequent than now.

To carry out this object, Francis Looney, F.G.S., a member of the Council, and at their request, devoted much valuable time in arranging for and giving a series of lectures, with chemical experiments, to the colliers in selected districts round Manchester, viz., Miles Platting, Oldham, Dukinfield, Flowery Field, Middleton, Irlams-o'-th'-Height, Walkden, and Clifton.

Notwithstanding the earlier success and the many memorials of good work recorded of the members in the Transactions of the Society, in a few years troubles of finance and of location began to crop up.

The falling away of early supporters, by death, removal, and other causes, reduced the annual income, but the one great obstacle to the continued prosperity of the Society appears to have been the difficulty of finding adequate accommodation for the meetings of the Society, and especially for the rapidly-growing museum, the expense of whose maintenance became a heavy burden on the funds of the Society.

Unfortunately, these circumstances caused a retrenchment of expenditure in the publications of the Society, by which many valuable papers which were read to the members have been lost to the present generation, their only record being their titles given in the minute books.

In the year 1849, owing to the difficulties in which the Society found itself, with a decreasing income and an

increasing expenditure, due largely to the Museum and its maintenance, the dissolution of the Society was seriously discussed, as well as the alternative proposition of the continuance of the Society, relieved of the burden of the Museum.

With a view of carrying out the latter project, the Corporations of Manchester and of Salford were approached, as well as the Councils of the Literary and Philosophical Society and the Natural History Society.

Deliverance from this embarrassing position came eventually at the latter end of the year 1850 from the Council of the Natural History Society, who offered that in the event of the collections of the Geological Society being permanently deposited in the building belonging to the Natural History Society in Peter Street (now the Young Men's Christian Association) their own geological collection should form part, and the united collections be open to the public free of charge.

Accommodation was also offered for the library and the meetings of the Society, free from any charge for rent. This offer on the part of the Natural History Society was unanimously accepted, and steps taken to prepare for removal.

In June, 1851, the Geological Society gave up the rooms it had occupied in the Royal Institution, and removed its collections, library, and effects to the Peter Street Museum.

Relieved of the heavy charge of rent, a brighter prospect appears now to have dawned upon the Society, a conclusion which is borne out by the Annual Reports of 1856 and 1858. The increase of members about this time was partly owing to the issue of a circular calling the attention of the land-owners, coal owners, and others interested in the mineral wealth of the district, to the claims of the Society; many of

the coal owners having up to that time, owing to a misapprehension of the objects of the Society, withheld their support.

This appeal led to a considerable addition to the list of members, in persons of note and influence, among whom were several largely interested in the collieries and industries of the district, and to some of whom the Society was afterwards greatly indebted for the active part they took in the proceedings of the Society and the promotion of its welfare.

Without being invidious I might name the Duke of Buccleuch, the late Lord Derby, the Hon. Algernon Egerton, Sir J. K. Shuttleworth, Bart.; Sir Humphrey de Trafford, Bart.; Sir Thomas Bazley, Bart.; Andrew Knowles, John Knowles, Thomas Knowles, M.P.; Peter Higson, R. P. Greg, Joseph Dickinson, Oliver Heywood, and R. D. Darbishire.

The time at my disposal will not permit me to record the events of succeeding years at large, a task which is perhaps needless, inasmuch as they are those common to the history of almost all institutions of like nature, and, moreover, they are not unknown to many of the members who are still active in the Society's service.

This sketch of the early years of the Society might be thought incomplete, however, if I did not extend it so far as to include that important incident in its history, when its collection of fossils, minerals, &c., which had been one of the distinctive objects of the Society's care and achievement for so many years, was transferred to the custody of the authorities of Owens College.

This abandonment of the Society's treasures was brought about by the accumulating difficulties which, as years rolled on, assailed the Natural History Society, whose Council found

themselves with a large building on their hands, and an inadequate income to maintain it and the collections under their charge.

In 1867, negotiations were afoot with the Owens College Extension Commissioners, the result of which was the transfer to the Owens College of the property and collections belonging to the Natural History Society, a decision which scarcely left the Geological Society any other choice than that of following a similar course, seeing the difficulty of obtaining adequate accommodation in any building in the centre of the city for the large collection which the Society had amassed.

An arrangement was therefore made with the Extension Committee of Owens College similar to the one made with the Natural History Society. This was embodied in a provisional agreement which was submitted to the members at two special general meetings for their confirmation, the latter of which was held in the Peter Street Museum on the 30th of November, 1869, when the proposal was assented to by the members then present.

The custody of the geological and mineralogical collections thus passed into the hands of the Owens College authorities for the use of the college and the benefit of the public. The right of members of the Manchester Geological Society to have access to the collections was specially reserved, as well as the important provision that the collections should be open to the public *without charge*, at least three days in each week.

Temporary arrangements were made for the continuance of the Society's meetings in the Peter Street Museum, until such date as the Museum buildings were wanted for other purposes. This respite from removal lasted for upwards of three years longer, until the time when the Museum was being divested of the collections, towards the end of the year

1873, an event which severed a connection between the Natural History Society and the Geological Society which had lasted for more than 20 years.

The Geological Society now freed from the charge of its Museum sought suitable and central rooms for its meetings and library elsewhere. An offer on the part of the Council of the Literary and Philosophical Society of the required accommodation in their house, 36, George Street, was accepted, and the 35th Annual Meeting of the Geological Society was held there in October, 1873, the actual tenancy commencing with the December quarter of the same year. The occupancy of these comfortable quarters continued till that quite recent period, of September, 1895, when the Geological Society had to give place to the increasing call for more room on the part of the Literary and Philosophical Society, for its own library, a fact well known to you all.

Thus another stage of 22 years in the life of the Society was completed.

In bringing to a conclusion this part of my address relative to the early history of the Society, my object has been to place before you the wise and liberal views of the founders, as expressed in the resolutions passed at the first meeting, as to the scope of geology in both its theoretical and practical aspects.

My aim has also been to stimulate the ardour and devotion of its present members in the endeavour to rival the good work done in the past,—to pray them to stand firm and united in the preservation, intact, of its original constitution, and thus to hand on to those who may succeed us an institution whose annals comprehend no mean part of the history of the intellectual life of Manchester and the county of which it forms part.

PART II.

Remarks on some questions of Speculative Geology.

After dealing as I have done in the preceding remarks with our own local and somewhat personal affairs, I may perhaps be permitted, so far as time allows, to refer to some of those questions of geological and popular interest, which have occupied the attention of the geological world during the existence of the Society.

That a great advance and large additions to our knowledge have been made in the various branches of geological science during this period, will be acknowledged by all who have acquaintance with the ever-increasing mass of geological literature, which threatens almost to overwhelm the student. New methods of research, chemical and mechanical, have come into use, which the older geologists had not at command. The microscope and photography have been the means of discovering many of the minute details of fossil organisms, as well as of revealing the secret mineral constituents and structure of many of the metamorphic and volcanic rocks.

It is not, however, to questions of this class that I propose to draw your attention, but rather to those more speculative problems in geology which have from time to time arrested public attention.

In a retrospect of geological doctrines many conflicts and changes of opinion are to be noted, due to the fact of the intricate and difficult problems that are presented for solution.

For instance, the great doctrine of the uniformity of Nature's operations, so powerfully advocated in "Lyell's Principles," in opposition to that of catastrophism once in vogue, has recently been attacked by able writers, who, by

the resuscitation of old-time arguments, seek to explain geological difficulties by hypotheses of convulsions and deluges, rather than by the slow and gradual changes in the organic and inorganic world, as postulated by Lyell, a view strongly supported by the modern doctrine of evolution.

Assuredly, every doctrine may be pushed to undue limits, outraging probabilities; but does it not seem a more reasonable proposition, that the ordinary operations of Nature, such as may be measured and investigated as going on around us, are more reliable data for induction than to call in as operating factors causes of which we have no evidence whatever? Moreover, may not the effects imputed to catastrophism be a phase of uniformity, due to the orderly working of some unknown law, as yet inexplicable?

This question of uniformity is closely allied to another problem which has been warmly discussed from many different points of view during recent years. I refer to "Geological Time," or the "Age of the Earth," a theme than which there is none more speculative or more barren of results in the whole range of geological physics, but which has had, nevertheless, a great fascination for physicists, mathematicians, and geologists alike. Geologists, disciples of Lyell, in the explanation of geological phenomena, assumed, as a rule, the duration of geological time as almost infinite, and equal to all demands that might be made upon it.

Some of these demands no doubt were extravagant, ranging as they did from a minimum of ten millions of years to five thousand million years and upwards,—estimates of time, the more modest of which the human mind fails to comprehend the duration.

On this question of geologic time, Lyell remarks, "by the geologist myriads of ages are reckoned, not by arithmetical computation, but by a train of physical events—a succession

of phenomena in the animate and inanimate worlds—signs which convey to our minds more definite ideas than figures can do of the immensity of time."

The conclusions of geologists as to the almost limitless extent of geological time received a severe shock at the hands of Lord Kelvin and Professor Tait in their "Treatise on Natural Philosophy," published in 1862, wherein geologists are warned that they must limit their estimates of geological time to some 10 or 20 millions of years.

Professor Tait asserted that the shorter term was all that their investigations into earth physics would permit.

Lord Kelvin's argument was derived from the consideration of the probable rate of cooling of the earth as a homogeneous mass of rock, an argument which seemed to be supported by the published calculations of Helmholtz as to the age of the sun, reckoned on the hypothesis of the uniform density of its mass and the mutual gravitation of its parts. On these grounds Professor Helmholtz limited the existence of the sun to some 18 millions of years at its present rate of radiation. To show how vain and misleading are often the conclusions of high authorities on such obscure topics, Lord Kelvin and Professor George Darwin would allow 500 millions of years as the maximum life of the sun, instead of the 18 millions of years accorded by Helmholtz.

Another argument put forward by Professor George Darwin in support of the limitation of the earth's age was that drawn from a consideration of the effect of tidal retardation on the earth's body, a line of argument that mathematicians have since shown to be faulty, owing to the uncertainty of the data upon which it is founded.

Numerous objections have been raised by geologists and mathematicians as to the validity of these arguments of the physicists, which are apparently based on assumptions whose correctness it is impossible to prove. Professor Perry has

shown in his letters to "Nature" last year that the data upon which Lord Kelvin's argument was based are not available, and his assumption as to the probable mode or rate at which the earth has cooled has no more solid foundation and no more value than any other assumption of the like kind, the results of which would vary accordingly.

Sir Archibald Geikie, in his Presidential address to the British Association Meeting, 1892, has remarked on the conclusions derived from the physicists point of view to the following effect: "It has been well said that the mathematical mill is an admirable piece of machinery, but that the value of what it yields depends upon the quality of what is put into it. That there must be some flaw in the physical argument, I can, for my own part, hardly doubt, though I do not pretend to be able to say where it is to be found. Some assumption, it seems to me, has been made, or some consideration has been left out of sight, which will eventually be seen to vitiate the conclusions, and which, when duly taken into account, will allow time enough for any reasonable interpretation of the geological record."

In justice to Lord Kelvin it should be remarked that in replying to Professor Perry's criticisms, he has seen fit to withdraw from his narrow time limit of the Earth's age, and says in his letter to *Nature*, 3rd January, 1895:—

"I thought my range from 20 millions to 400 millions was probably wide enough, but it is quite possible that I should have put the superior limit a good deal higher, perhaps 4,000 instead of 400."

This larger limit would probably satisfy the majority of geologists.

From the geologists or Darwinian point of view, this limitation of geological time to some 10 or 30 million years was utterly inadequate to accomplish the work that the

geological record indicated, and which the theory of organic evolution requires.

The late Charles Darwin thought that 200 millions of years was scarcely sufficient for the gradual evolution of organic life, plant and animal.

It has been assumed however by some eminent authorities that geological change was greater in the very remote past than now, but where, it may be asked, is the evidence of it?

Sir Archibald Geikie in his address that I before referred to, sees no proof of this during Mesozoic or Palæozoic time, and the biologist would be entering upon unsafe ground if he assumed that the rate of change in organic life has been either greater or less in ancient times than it is now. A well-known American geologist, G. K. Gilbert, has recently made an attempt to estimate the length of time necessary for the accumulation of certain beds of shale and limestone belonging to the Cretaceous system in the Arkansas river basin, taking into account the probable time necessary for the growth, development, and modification of the various fossil organic forms found therein. He says, "that it would require some 20 millions of years for the deposition of this portion of the Cretaceous series, representing perhaps half of the Cretaceous period."

When we consider that every mineral, every sand-grain has its history, each fossil its biography, its part and place in the grand process of the evolution of life on our globe, we cannot wonder at the amount of time demanded of Nature by the geologist or palæontologist.

If we were to analyse the other sedimentary formations from the earliest Cambrian strata to the latest deposit on the ocean bed, in the same way as Mr. Gilbert has done with a portion of the Cretaceous, the result would be a demand for an amount of time, whose computation resists man's feeble attempts at earth chronography.

To this estimate of geologic time, we must add that demanded by the age of the *Pre*-Cambrian rocks, those foundation rocks of the earth's crust known under the various names of Azoic, Archæan, and Igneous, which would probably be a draft on the bank of time, far exceeding that of the stratified or sedimentary rocks. From all this evidence, of which I have only given you a mere outline, we may at least gather the one substantial fact, that the earth is very old, and that its age can scarcely be expressed or understood by any formulæ of mere figures.

A quarter of a century after the foundation of our Society, another question of speculative enquiry and of geological interest excited great discussion among geologists and the public. I refer to the question of the Antiquity of Man.

Though man may be considered as the latest birth of time, yet he is connected by many memorials with that prehistoric past, when profound changes in the climate of the Northern Hemisphere were being experienced over Northern Europe and America, resulting in what is known as the "Great Ice Age."

Many of you will remember the heated and often angry debates that occurred at the meetings of the British Association and other learned Societies when friends were often ranged in opposite camps, the one appealing to tradition and sentiment, while the other relied upon the scientific evidence that geological research supplied.

These struggles are now happily silenced by the general acceptation of the doctrine of man's antiquity—a doctrine which has been fully proved by the geological researches in ancient river valleys, in caverns, and rock shelters, where human bones and man's handiwork are associated with the remains of extinct mammalia under circumstances which demonstrate a very high antiquity.

The debate, however, is still prolonged as to whether man is pre-glacial or post-glacial, but of the former contention there is as yet no satisfactory evidence.

Had time permitted, I might have said a few words on another great question of geological speculation, that of the *Cause* of the Ice-Age, a subject that still engages the attention of the scientific world. Suffice it to say, that notwithstanding the various attempts at explanation of astronomers, physicists, and geologists, there is no theory hitherto propounded that fully satisfies geological requirements.

There is more hope, I take it, of arriving at a satisfactory solution of the many geological enigmas of the "Ice Age" by practical explorations in the glaciated regions of polar lands, by competent geologists and naturalists, than by astronomical hypotheses, however helpful they may be in suggesting extra-cosmic influences, as the cause of climatic change.

Such researches, it is satisfactory to note, are being made by accomplished explorers and trained geologists in such recent expeditions as those of Nansen, Jackson Harmsworth, the American Peary, and others, details of which are being prepared and will in due course be in the hands of the public.

Although I have thus only spoken of a few of the theoretical questions that interest geologists, fascinating though they be, it must not be forgotten that while geology treats of much that influences the imagination, yet it is a science very practical in its application to industrial pursuits, a point of view which is not likely to be disregarded by the members of the Manchester Geological Society.

In the exploitation of our coalfields, iron ores, salt deposits, and other mineral treasures,—the main sources of

England's greatness,—the teachings of geology are our safest guide to their proper exploration and utilization.

In the rush for the search of the precious metals, which at the present day is so remarkable a feature in some of our colonies, populating hitherto desert tracts with a swarming population, it is not random or haphazard ventures that are likely to be successful, but those only which are directed by scientific experience and observation, gained in the field often at great personal risk.

There are many other practical applications of geological knowledge besides mining, of which our Society takes cognizance, as, for instance, the search for and utilization of underground water, a commodity now eagerly inquired for to supply the needs of the ever-growing town populations.

I think that I have said enough to show that the objects of our Society—"the collection and diffusion of practical and theoretical knowledge respecting geology and mining"—are sufficiently wide and embracing to enlist the support and tax the spare energy of each and every member who is wishful to help and maintain the Society in a career of continued prosperity and usefulness.

Our Society ought to be the centre in the wide district of "Greater Manchester," around which all lovers of geology as well as representatives of the practical side of the science should rally for mutual support and benefit. The meetings of the Society offer an opportunity for the exchange of ideas and the utilization of any special information that a member may possess, thus reciprocally aiding in the advancement of our common object, the welfare of the Society, and the dissemination of useful information among the members. That the Society may continue to flourish is the ardent wish of your President.

Mr. WATTS in moving a vote of thanks to the President said: I am proud to belong to a Society which had such eminent men to introduce it to the people of the north of England, and I think, as the successors of those men we in the present day are bound to do whatsoever in us lies to maintain the efficiency and usefulness of the Society. I see no reason why the Manchester Geological Society should not be made for the north of England what the London Geological Society is for the southern portion of the kingdom and the United Kingdom. It rests with ourselves what it shall be in the future. The President has very lucidly, and in a very interesting manner, told us what its beginnings were and who were the men who founded it, and what sacrifices they made, and I think its past history should be an incentive to all of us, as we meet month by month, to strive to make this Society a really first class Geological Society for the north of England. In the latter part of his address the President trod upon somewhat delicate ground, for the questions upon which he touched are largely debateable. I am a believer in the length of geological time. There is no reason—from my knowledge of geology—why a long time should not be allowed for the earth's evolution. The subject, however, is a very wide one and hardly admits of being debated now. The President, I am sure, deserves our warmest thanks, and I propose that they be given to him for his address.

Mr. JOSEPH DICKINSON said: I have great pleasure, Mr. President and gentlemen, in seconding the motion of Mr. Watts. The preparation of his address must have cost the President a very great deal of time and research. He has spoken of the time when the minute books were preserved. There was, I may say, at that time, some little anxiety on the subject, some contention arose on the part of the Natural History Society, who put in a claim to those old

books, but the members of this Society sternly insisted on their right to its records, and they were at length given over to the possession of Mr. H. M. Ormerod, representing our Society. Mr. Ormerod, I think, is the only member now living whose connection with the Society dates from its foundation in 1838.

The PRESIDENT: Except Mr. James Heywood.

Mr. DICKINSON: I am, myself, comparatively a new member, having joined the Society in 1856—only 40 years ago. I have seen during the course of my membership influences at work in the Society which the President has not referred to. There was at the date I mention not a little feeling amongst the members arising out of the then-existing rule that the oldest Vice-President should always, in the absence of the President, take the chair at the ordinary meetings. Thus it happened almost uniformly that the meetings were presided over by one member (the President himself being rarely present), and he, a most able conchologist, but being very deaf, he was quite unable to control the meetings over which he presided. These things, of course, rectified themselves in time. Then, not only was there the difficulty of finding rooms; it was a much greater difficulty to find members to fill the rooms, and to inspirit the Society. But that was at length surmounted, and ever since the body has gone on and prospered. There may have been little undulations, so to speak, in the interest of the papers presented to us, but we have had most useful papers and I have not noticed in any respect any falling off in recent years. Certainly, if you were to look back forty years and see the sluggish way in which the Society then was, its present prosperity and the spirit which animates all its members would cheer your hearts. I do not know that there is anything further to which I should allude. We

have had I may say, from time to time, most able men joining the Society, but none have done more active and useful work than our present President. It would take a long time to recapitulate all the service he has been to the Society. We have been very much indebted to him, as well as to others, whom it might be invidious to name, but we cannot avoid in this connection singling out Mr. H. M. Ormerod and Mr. James Heywood, the only survivors of the founders of the Society. There was also Dr. Black, who at one time made some most useful contributions, and whose son takes an interest in our proceedings. Looking back over the past forty years, I am pleased to see the Society flourishing as it is, and I would only impress upon the members, one and all, to endeavour to increase the interest of our proceedings by contributing useful papers. When a useful and interesting paper is announced for any meeting it is wonderful how the attendance is increased. I have much pleasure in seconding the vote of thanks to the President.

Mr. Watts, before putting the resolution to the meeting, said: I should like, gentlemen, to give expression to a desire I have long felt that we should have the portraits of some of the old and distinguished members of this Society, if they could be got hold of, placed upon its walls. I think it is a pity that we are not able to look upon the features of some of those who have passed away when we meet in these rooms. The President, in his address, referred to the Peter Street Museum, an institution with which I have many pleasing associations. I remember sitting along with the President on the same form, listening to the lectures of Professor Dawkins. I have always felt that there was no place in Manchester where it was more agreeable to the geologist to listen to lectures than that old institution, and I regretted when the time came for us to remove from the old Peter Street building.

The vote of thanks to the President was passed with acclamation.

The PRESIDENT, in acknowledging the vote, said: My object in this paper was that, besides bringing before you the facts it contains, the Society should have, in a condensed form, for preservation, some account of its foundation and early history. I knew of none previously existing. I received this morning a letter from an old friend (Mr. John Ward) who would gladly have been here if it had been possible. He says: "For over 30 years I have been interested in the work of your Society. I was acquainted with several of its past Presidents years ago, and I never went to Manchester without visiting the old Museum in Peter Street to have a talk with old Parker." I dare say few of those present will remember old Parker. No doubt Professor Dawkins will remember him well, as I do myself. The writer of the letter expressed a wish to have a copy of my address to remind him of old times and associates who had "joined the majority." Mr. Ward knew Mr. Binney and many other old members of this Society. He often visited the rooms in George Street when we were located there, and had talks with me about old times and what we were doing. Mr. Ward is the author of Geology of the Staffordshire Coalfield, and his collection of fossils from that coalfield, as you may know, is now in the British Museum. I have had other letters from gentlemen who were not able to be present this afternoon; but I presume they are looking forward to the address being published.

Mr. DICKINSON: Referring to "old Parker," I would just like to add a reminiscence. He was Assistant Curator at the Museum, and an exceedingly useful man. When this Society had got down to about its lowest depth—now getting on for 40 years ago—a meeting was convened of those who were anxious to see it resuscitated. The only

members present were Captain Brown (who was in the Chair), Mr. E. W. Binney, Mr. Parker, and myself. I am happy to say the gentlemen of the Press also favoured us with their presence, and in the reports they gave of that meeting they were good enough to put the best face upon matters, for in describing the attendance they spoke of Captain Brown as Presiding, and "amongst others present," Mr. E. W. Binney, Mr. Joseph Dickinson, &c.—Mr. Parker being the "&c." "Old Parker" really did perform some useful work, not only as Assistant Curator of the Museum, but also in helping to preserve this Society from becoming defunct.

The President announced that arrangements had been made for holding an evening meeting—in addition to the Ordinary Meeting in December—probably on the Friday before Christmas, when Messrs. Barnes and Holroyd would give them another paper. Other members who might have papers in preparation for presentation during the session, would greatly oblige if they would communicate with the Hon. Secretaries.

This concluded the business of the meeting.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART III. VOL. XXV. SESSION 1896-97.

The ORDINARY MEETING of the Members was held on Tuesday, December 8th, 1896, at the Society's Rooms, Queen's Chambers, John Dalton Street.

The President, Mr. MARK STIRRUP, F.G.S., in the Chair.

NEW MEMBERS.

The following gentlemen were balloted for and duly elected Ordinary Members of the Society:—

Mr. ROBERT HUMPHREY, F.S.A. (Scot.), 12, King Street, Manchester.

Mr. NORMAN FLETCHER, Ladyshore Colliery, Little Lever.

Mr. LEONARD FLETCHER, Atherton Collieries, Atherton, Manchester.

FURTHER REMARKS ON THE DURHAM AND CLEVELAND SALT DISTRICTS.

BY MR. THOMAS BELL, J.P.,

One of the Honorary Members of the Society.

In the year 1890 I wrote a short paper pointing out that from the last or east-most boring at Lackenby, 1806 feet, there were no signs or proof that the Lias overlies or over-

laps the new red sandstone measures at this point or otherwise, but was full of hope that the then state of the salt trade would warrant further developments. This has unfortunately not taken place, in consequence, I presume, of the low price obtained for the manufactured white salt; indeed the Lackenby Well, after having been completed, and part of the machinery erected, has never been started, and no other well has since been sunk outside the known area of the Clarence (Durham) and Middlesbrough (Yorkshire) salt district.

The following table, giving the annual production of white salt in this northern district for the years 1889-1895 inclusive, may be interesting to many of our readers:—

	Durham.	Yorkshire, North Riding.	Total Tons.
1889	191,647	26,500	218,147
1890	199,971	35,700	235,671
1891	200,507	50,042	250,549
1892	180,645	50,415	231,060*
1893	241,020	48,178	289,198
1894	255,808	62,199	318,007
1895	243,971	55,509	299,480

A borehole was put down at Seaton Carew, about midway between Greatham and West Hartlepool, and considerably to the north of the known salt bed in 1887 and 1888 by the Diamond Boring Company (Mr. John Vivian), for Mr. C. T. Casebourne, C.E., where it was proved that the salt rock did not exist at the point expected, viz., at a depth of near 500 feet; but at 606 feet rock oil was found, and sulphurous water was met with, and at 1153 feet a brine feeder was got. The salt bed being usually met with between the main beds of anhydrite; this boring was continued through the Magnesian Limestone at 1400 feet, proving 878 feet in thickness of this rock; the boring has been continued to a total depth of 1814½ feet, and Carboniferous strata proved below the Magnesian Limestone. These,

* Three months Durham coal strike.

with the 10 inches and 14 inches coal seams, all form elements for consideration as to their exact geological position. A detailed section of this boring is appended.

I also append a boring below the salt bed through the Magnesian Limestone and into the Coal Measures at Haverton Hill, a short distance north-west from Middlesbrough, but on the Durham side of the River Tees.

The Company, Messrs. C. Allhusen & Sons, being of opinion that from the geological position of their wells, with occasional escapes of gas, that by boring deeper, gas would be met with sufficient to evaporate the brine, and thus save the heavy cost of fuel; consequently an arrangement was made, and the American boring system was put in operation at their No. 8A Well from the bottom of the saltbed, 808 feet, and continued to a depth of 2,173 feet, but as the quantity of gas met with was small, and the project disappointing, the scheme was abandoned in November, 1891, since which time no further attempt has been made in this direction.

The Lackenby section was printed with my paper in 1890.

The section at Haverton Hill, as well as the Seaton Carew, is here appended.

No. 8a, Boring by the American System at Haverton Hill (Co. Durham), for the United Alkali Company, Limited, (Messrs. C. Allhusen & Sons,) completed November 18th, 1891.

	Description of Strata.	Thickness of Strata. ft.	in.	Depth from Surface. ft.	in.
1.	Ordinary surface soil, &c.	5	0	5	0
2.	Blue clay	30	0	35	0
3.	Sand and clay	15	0	50	0
4.	Sand and gravel	15	0	65	0
5.	Gravel	5	0	70	0
6.	Soft sandstone	5	0	75	0
7.	Red sandstone	325	0	400	0
8.	Red marl	332	0	732	0

	Description of Strata.	Thickness of Strata. ft.	in.	Depth from Surface. ft.	in.
9.	Anhydrite	9	0	741	0
10.	Rotten marl containing salt	25	0	766	0
11.	Rock Salt	42	0	808	0
12.	Light grey limestone	93	0	901	0
13.	Dark grey limestone	18	0	919	0
14.	Light grey limestone	313	0	1,232	0
15.	Dark grey limestone	42	0	1,274	0
16.	Black and red shale	41	0	1,315	0
17.	Sand and water, gas bubbles	48	0	1,363	0
18.	Black and red shale	6	0	1,369	0
19.	Grey limestone	20	0	1,389	0
20.	Shale	18	0	1,407	0
21.	Sticky substance like fireclay	17	0	1,424	0
22.	Dark limestone	8	0	1,432	0
23.	Sand	9	0	1,441	0
24.	Sand and limestone	18	0	1,459	0
25.	Sand	20	0	1,479	0
26.	Shale and fine clay	20	0	1,499	0
27.	Fire-clay	36	0	1,535	0
28.	Shale	9	0	1,544	0
29.	Grey limestone	35	0	1,579	0
30.	Black shale	18	0	1,597	0
31.	Sandstone	7	0	1,604	0
32.	Sandstone and shale	11	0	1,615	0
33.	Limestone and shale	8	0	1,623	0
34.	Sandstone	30	0	1,653	0
35.	Limestone	11	0	1,664	0
36.	Light grey sandstone	9	0	1,673	0
37.	Dark sandstone and shale	21	0	1,694	0
38.	Shale	44	0	1,738	0
39.	Black shale	16	0	1,794	0
40.	Black shale	24	0	1,778	0
41.	Limestone	16	0	1,794	0
42.	Grey sandstone	19	0	1,813	0
43.	Sandstone mixed with shale	20	0	1,833	0
44.	Fine sand with water	16	0	1,849	0
45.	Black shale and sand	13	0	1,862	0
46.	Shale	53	0	1,915	0
47.	Grey limestone	12	0	1,927	0

	Description of Strata.	Thickness of Strata. ft.	in.	Depth from Surface. ft.	in.
48.	Grey limestone with a little shale	12	0	1,939	0
49.	Grey sandstone..	5	0	1,944	0
50.	Shale and a little sand..	6	0	1,950	0
51.	Coal and a little gas	2	0	1,952	0
52.	Limestone	6	0	1,958	0
53.	Sandstone	14	0	1,972	0
54.	Sandy shale and a little gas	2	0	1,974	0
	Bored from here with the Diamond Drill, 25th August, 1891.				
55.	Hard shale..	3	0	1,977	0
56.	Hard black shale	9	0	1,986	0
57.	Grey sandstone..	2	0	1,988	0
58.	Black shale	2	0	1,990	0
59.	Grey micaceous sandstone	8	0	1,998	0
60.	Black shale	11	0	2,009	0
61.	Limestone	26	0	2,035	0
62.	Grey micaceous sandstone	7	6	2,042	6
63.	Grey micaceous sandstone with veins of shale	32	0	2,074	6
64.	Hard black shale with veins of sandstone	6	0	2,090	6
65.	Micaceous sandstone	9	0	2,089	6
66.	Hard shale..	3	0	2,092	6
67.	Micaceous sandstone	8	0	2,100	6
68.	Hard grey shale	3	6	2,104	0
69.	Hard black shale	48	6	2,152	6
70.	Dark sandy shale	3	6	2,156	0
71.	Left off in hard black shale	17	0	2,173	0

Diamond Boring near Seaton Carew (Co. Durham), by Mr. John Vivian, for Mr. C. T. Casebourne, 1887, 1888.

	Description of Strata.	Thickness of Strata. ft.	in.	Depth from Surface. ft.	in.
1.	Brown clay..	6	0	6	0
2.	Red clay..	6	0	12	0
3.	Red pinnel and cobbles	6	0	18	0
4.	Soft red sandy marl	12	0	30	0
5.	Red sandy marl..	3	0	33	0
6.	Red and grey sandstone	7	0	40	0

	Description of Strata.	Thickness of Strata. ft.	in.	Depth from Surface. ft.	in.
7.	Red marl	2	0	42	0
8.	Grey sandstone	5	0	47	0
9.	Red marl with beds of sandstone	10	0	57	0
10.	Red sandstone	20	0	77	0
11.	Grey do.	2	0	79	0
12.	Red do.	13	0	92	0
13.	Grey do.	1	0	93	0
14.	Red sandy marl	47	0	140	0
15.	Red and grey sandstone	10	0	150	0
16.	Red marl	15	0	165	0
17.	Red marl with beds of red and grey sandstone	8	0	173	0
18.	Red marl with blue joints	35	0	208	0
19.	Red marl with blue joints and beds of grey sandstone	24	0	232	0
20.	Red marl with beds of grey marl	33	0	265	0
21.	Red marl with blue joints	24	0	289	0
22.	Red marl with blue joints and beds of gypsum	171	0	460	0
23.	Red marl with veins of gypsum	7	5	467	5
24.	Anhydrite	13	0	480	5
25.	Blue marl with veins of gypsum	3	0	483	5
26.	Anhydrite	1	0	484	5
27.	Red marl with veins of gypsum (rotten marl)	10	0	494	5
28.	Dark marl and gypsum mixed	2	7	497	0
29.	Anhydrite with black joints	25	0	522	0
30.	Magnesian limestone with spots of gypsum	27	0	549	0
31.	Light grey magnesian limestone with spots and veins of gypsum	38	0	587	0
32.	Dark grey limestone with spots and veins of gypsum	16	0	603	0
33.	Dark blue shale with small feeder of rock oil and sulphur water	3	0	606	0
34.	Anhydrite with beds of dark blue shale and gypsum	35	0	641	0
35.	Light grey limestone and gypsum	7	0	648	0
36.	Blue shale	2	0	650	0

	Description of Strata.	Thickness of Strata. ft.	in.	Depth from Surface. ft.	in.
37.	Light grey limestone	11	0	661	0
38.	White limestone	90	0	751	0
39.	Hard white limestone with gypsum....	12	0	763	0
40.	Dark grey limestone and anhydrite ..	20	0	783	0
41.	Light grey limestone with gypsum	18	0	801	0
42.	Light grey limestone	29	0	830	0
43.	Limestone and gypsum mixed	31	0	861	0
44.	Grey limestone with gypsum.	11	0	872	0
45.	Light grey limestone and gypsum	33	0	905	0
46.	Light grey limestone	50	0	955	0
47.	Light grey limestone with spots of gypsum	45	0	1,000	0
48.	White limestone	107	0	1,107	0
49.	Light grey limestone	23	0	1,130	0
50.	Broken light grey limestone and brine spring	23	0	1,153	0
51.	Light grey limestone	9	0	1,162	0
52.	Light grey limestone with spar cavities.	9	0	1,171	0
53.	Light grey limestone	7	0	1,178	0
54.	White limestone	82	0	1,260	0
55.	Light grey limestone with a little gypsum	23	0	1,283	0
56.	Dark grey limestone with gypsum ..	17	6	1,300	6
57.	Dark grey limestone with veins of gypsum	19	6	1,320	0
58.	Dark limestone with spots of gypsum ..	40	0	1,360	0
59.	Dark grey limestone	40	0	1,400	0
60.	Dark grey shaly sandstone	10	0	1,410	0
61.	Red and grey shaly sandstone	17	6	1,427	6
62.	Black shale..	0	6	1,428	0
63.	Dark grey shale	1	0	1,429	0
64.	Dark grey sandstone	1	0	1,430	0
65.	Grey sandstone with black joints	30	0	1,460	0
66.	Grey sandstone..	10	0	1,470	0
67.	Very coarse grey sandstone	15	0	1,485	0
68.	Dark grey sandstone	0	6	1,485	6
69.	Black shale	0	6	1,486	0
70.	Red and grey sandstone	1	7	1,487	7

	Description of Strata.	Thickness of Strata. ft.	in.	Depth from Surface. ft.	in.
71.	Black shale	12	4	1,499	11
72.	Shaly sandstone	2	6	1,502	5
73.	Black shale	10	0	1,512	5
74.	Grey sandstone	4	0	1,516	5
75.	Dark grey sandy shale	0	7	1,517	0
76.	Coal	0	10	1,517	10
77.	Dark brown fireclay	1	2	1,519	0
78.	Black sandy shale	2	8	1,521	8
79.	Dark Grey sandy shale	1	8	1,523	4
80.	White sandstone	26	8	1,550	0
81.	Dark grey sandstone	5	0	1,555	0
82.	Light grey sandstone	12	8	1,567	8
83.	Dark shaly sandstone with coal joints	1	4	1,569	0
84.	Black shale	9	6	1,578	6
85.	Coal	1	2	1,579	8
86.	Dark black shale and fireclay	0	4	1,580	0
87.	White and grey sandstone	6	0	1,586	0
88.	Black shale	8	0	1,594	0
89.	Fine grey sandstone	6	0	1,600	0
90.	Dark grey sandstone	3	6	1,603	6
91.	Black shale	7	0	1,680	6
92.	Black shale with beds of dark grey sandstone	6	6	1,617	0
93.	Black shale	6	0	1,623	0
94.	Black shale with beds of grey sandstone	7	11	1,630	11
95.	Coal and shale	0	1	1,631	0
96.	Dark brown fireclay	2	0	1,633	0
97.	Dark gray sandstone	6	0	1,639	0
98.	Dark shaly sandstone	5	0	1,644	0
99.	Yellowish sandstone	8	9	1,652	9
100.	Coarse light grey sandstone	16	6	1,669	3
101.	Hard yellowish sandstone with lime veinule	2	3	1,671	6
102.	Coarse light grey sandstone	3	6	1,675	0
103.	Coarse grey sandstone	1	6	1,676	6
104.	Dark grey shaly sandstone	1	6	1,678	0
105.	Black shale	8	0	1,686	0
106.	Dark grey sandy shale	3	0	1,689	0

	Description of Strata.	Thickness of Strata. ft.	in.	Depth from Surface. ft.	in.
107.	Dark blue shale	7	0	1,696	0
108.	Black shale	4	0	1,700	0
109.	Dark brown shale..	3	0	1,703	0
110.	Grey shaly sandstone	10	0	1,713	0
111.	Coarse grey sandstone with coal pipes..	24	0	1,737	0
112.	Dark grey shaly sandstone..	5	0	1,742	0
113.	Yellowish shaly sandstone	6	0	1,748	0
114.	Dark shaly sandstone	8	0	1,756	0
115.	Black shale	24	0	1,780	0
116.	Grey sandstone with beds of black shale	10	0	1,790	0
117.	Coarse grey sandstone with black joints	10	0	1,800	0
118.	Grey sandstone	14	6	1,814	6

Mr. Dickinson, after reading the paper, said: You will allow me to move a vote of thanks to Mr. Bell for his valuable communication. With this paper, by our Honorary Member, we have the Cleveland and Durham salt explorations up to date. It is true that the paper has been delayed owing to crowding out last session, but from what Mr. Bell informs me there has been a slack autumn in the northern salt trade, and not any new borings attempted, hopes, however, being entertained that extended railway enterprise will help to further develope the salt district. It will not fail to be observed by Mr. Bell's paper that he keeps pegging away relative to no proof having yet been discovered that the Lias formation overlies the salt beds at Middlesbrough. This is an interesting geological point, and it is quite clear from the Haverton Hill and Lackenby sections that the Lias does not in either overlie as prematurely supposed; and also, from the borings generally, that the salt is not in the marls immediately underneath the Lias, but is in marls underneath a bed of red sandstone 800 feet in thickness. The same point as to the absence of actual proof of the position of the salt beds

was mentioned by me in my inaugural address before this Society in 1887, in which I hoped that distinct proof might be made, which could easily be done either at the Middlesbrough saltfield or in Shropshire with the outlying Cheshire saltfield. The Seaton Carew section, now given by Mr. Bell, is specially important in showing an actual thickness of 878 feet of Magnesian Limestone underneath the salt beds. This thickness, so far as I am aware, is the greatest hitherto actually penetrated. Hitherto the greatest thickness that I have seen mentioned in geological works is about 600 feet at Castle Eden, and even that was not actually proved, the depth to it there, as given to me by Mr. Bell, being 73 feet, and to the bottom 633 feet, leaving a balance of only 560 feet; whereas at Seaton Carew the depth now shown is 522 feet to the first bed of limestone, and 1,400 to the bottom of the deepest bed, proving the total thickness of the Magnesian Limestone there to be 878 feet.

Mr. Saint: I have much pleasure in seconding the vote of thanks to Mr. Bell.

The motion was passed unanimously.

The President then invited discussion. Several interesting points, he said, had been brought forward, upon which he would be glad to hear the opinions of gentlemen present. The object of the borings, he understood, was to find coal, and two coal seams had actually been reached.

Mr. Dickinson: Yes, they are shown in the sections, and the thickness of each bed is indicated.

The President: But there is no working of them at present.

Mr. Dickinson: Oh, no.

The President: Those sections should be printed in the Transactions. They will be very important data for reference. All such sections are valuable, whether the borings

are for water, coal, or salt, and we are always very glad to have them shown at our meetings. There has been a difference of opinion as to the exact position of the saltfields in the Durham and Middlesbrough district, but these sections appear to fix it. Professor Hull has said that there are two distinct beds of salt—the one in the Trias (as in the case of our Cheshire salt beds) and the other in the Permian. This view, however, has been contested in some quarters, the age of the rocks being questioned, and all the salt beds claimed to belong to the saliferous marls of the Trias. Now, as far as I can gather from what Mr. Dickinson has read, these salt deposits occur *above* the Permian or Magnesian Limestone, and there is no trace of the Lias. Well, they would naturally come, in the usual order of stratification, under the Lias rocks if there were any present there.

Mr. Dickinson: There is Lias in that district in abundance, but the question is whether these saliferous marls in Cleveland abut against the Lias formation or lie underneath it. That is the point.

The President: I am not sufficiently acquainted with the district to know whether anything like faulting has taken place, but the position of the saliferous marls, according to their natural sequence, would, of course, be under the Lias, in the upper beds of the Trias, where the salt measures usually occur, and underneath them, if present, the Magnesian Limestone. We have little to show of the Magnesian Limestone in Lancashire, but I believe it is represented in the neighbourhood of Patricroft and at Bedford Leigh by a thin bed. Mr. Dickinson says that in Durham the Magnesian Limestone reaches a thickness of 878 ft., which is very great indeed. There is a bed of marl slate also, which is very important, from its containing, where it crops out on the sea-coast in the North, fossils of fish, of which good representative collections may be seen in the museums of

Newcastle-on-Tyne and elsewhere. As to Natural Gas, I do not think we have in Britain any important sources of it, such as those which are largely drawn upon in the United States for lighting and heating purposes. Such reservoirs as have been found in this country, though they may have served a temporary purpose, have become quickly exhausted.

Mr. L. B. WELLS, C.E. (who was called upon by the President) said: I am afraid I have no knowledge of this district at all. My knowledge of the Cheshire saltfield is more practical than geological. I have had to investigate a number of borings made in different parts of the district. It differs, of course, entirely from the Middlesborough one, which is the subject of this paper. In Cheshire we have a copious supply of brine, comparatively near the surface, and the great desire is to get hold of a natural brine run and pump away. Some of these have been pumped for a great number of years, and have supplied millions of tons of salt. The opening up of the saltfield in the East of England has been almost a death blow to the prosperity of the Cheshire salt district. The 300,000 tons that have been made in the neighbourhood of Middlesbrough has all, practically, been taken away from Cheshire, I think; and consequently the people who have been relying for their employment on Cheshire salt have had, many of them, to go into the Middlesbrough district, some also into Lancashire, to the neighbourhood of Fleetwood. I was surprised to hear that the price of salt had been a bar to further exploration. The price of salt is, I think, rather high now, compared with the price ruling ten or fifteen years ago, when the Cheshire trade was very prosperous, owing to the Salt Union having put up prices. I think the putting up of the price by the Salt Union was almost the one thing which enabled these other saltfields to be developed. Some years ago, when there was a large chemical trade in the neighbourhood of

Newcastle (I think much larger than now), Cheshire salt was sent there in very large quantities. But, geologically, I think the two districts are entirely separate, and the method of getting the salt is different, as, from what I have heard of the East Coast, they pour water down, or take means to let water down, whereas in Cheshire there is little done in that way. It is a natural brine they seek for in the first instance; failing that they frequently pump from an old rock salt mine. I do not know if any gentleman here can tell us whether there are any subsidences caused by the removal of rock salt by pumping on the East Coast. That would be an interesting thing to know. I am not aware of any—nor have I heard of any—but I believe at Fleetwood they are suffering from that trouble, which has prevailed in Cheshire for many years past. Mr. Dickinson and I have been engaged at different times in reference to a Bill—which has ultimately become an Act—to compensate the surface owners for damage done, and that Act is now coming into operation. The Board has been formed who are to see to the claims made, and adjudicate upon them; and I suppose within a few months there will be some distributions made to the sufferers.

The PRESIDENT: I have not heard of any subsidence having taken place in the Middlesbrough district. Of course the salt beds there lie at a much greater depth, and, therefore, the surface is supported by a much greater mass of rock, and subsidence is not apprehended.

Mr. W. F. HOLROYD: Did I understand Mr. Dickinson to say that mineral oil had been found in these borings?

Mr. DICKINSON: Yes.

Mr. HOLROYD: I would further like to ask if any member knows anything of the salt deposits in the northern part of the Isle of Man. I understand some discoveries have been made there within the last year or two of saliferous beds in

the northern part of the island, and these will probably be a continuation of the beds in North Lancashire. If such is the case, can any information be given as to the working of those beds?

Mr. Dickinson: That question can very readily be answered. A year or two ago Professor Boyd Dawkins laid before this Society the sections that were proved in the north of the Isle of Man in boring through the rock salt, and they are to be found in our Transactions. The beds have not been opened out.

Mr. Holroyd: The point I wanted information upon was whether any practical or economical use had been made of the discovery.

The President: Those beds have not been worked commercially.

Mr. Dickinson: I would like, before the discussion is closed, to refer to what Mr. Wells said about subsidence. I believe none has taken place yet in the Middlesbrough district; in fact, that thick bed of sandstone, which is nearly 300 yards thick, will serve as a protection for a very long time to come. I noticed that none of the speakers touched upon the point with which Mr. Bell opened his paper, except the President, namely, as to the position which the saliferous beds hold with regard to the Lias. On this point I made the following statement in the Inaugural Address which I read before this Society in 1887:—

"The superposition of the principal formations appears to be now well authenticated, but probably there is still something to learn respecting the connection of the Wealden, the Lias, the Trias, and the Permian. The similarity in some of the beds in the Trias and the Permian makes it sometimes difficult to distinguish one from the other where the Permian fossils are absent. The whole of these, with the overlying saliferous marls, are placed under the Lias,

which is countenanced by general indications in Durham, Yorkshire, Cheshire, and Worcestershire. But I may say that it would be satisfactory if geologists made known any instance where rock salt (not brine only) had been actually penetrated underneath the Lias, and thus remove the doubt which exists with some persons whether the saliferous marls do not abut against the Lias and other rocks, and hold a higher position in the series than that assigned."

ON IRRUPTIONS OF COAL INTO THE "THICK COAL" WORKINGS AT HAMSTEAD COLLIERY, SOUTH STAFFORDSHIRE.

By Mr. Frederick G. Meachem, M.E.

Communicated by Mr. Joseph Dickinson, F.G.S.

In April, 1893, the author gave before the South Staffordshire and East Worcestershire Institute of Mining Engineers, a description of an irruption which had then occurred, designated an "earth explosion," locally called a "bump," which took place November 5th, 1892, in the "Thick Coal" workings at Hamstead Colliery, in South Staffordshire.

Since then several very serious irruptions of like kind, but of adjoining strata as well as coal, have issued into the workings; a few details of some of which it is hoped may be usefully brought under the notice of the Manchester Geological Society.

It may be stated preliminarily, for the fuller understanding of the circumstances, the depth of the shafts to the top of the seam of coal is 620 yards. The dip of the seam is North-eastward, at the rate of about 1 in 16. The total

thickness of the seam, including partings, is about 24 feet The gateroads or roadways in the seam are ordinarily driven 9 feet wide at the bottom, and so shaped as to admit of being supported by double timbers or couplings 7 feet high with 6 feet cross-bars at the top; the timbers being usually of larch, 6 to 8 inches in width, and placed always only 18 inches apart, with lagging poles and oak slabs above.

The seam is divided into layers, varying somewhat in thickness, nearly as shown in the following section:—

	Feet.	Ins.
Roover coal	2	0
Top Slipper coal	1	8
White coal / Tow coal	4	5
Parting	0	1
Brassils coal, soft	4	4
First Batt	0	6
Slip coal, soft	1	9
Stone coal, soft	2	6
Second Batt	0	6
Sawyer coal, soft / Slipper coal	4	4
Bench Batt	0	8
Bench coal, soft	1	3
	24	0

All the layers are liable to spontaneous combustion when broken, the soft coal being specially liable.

The grain or face of the coal runs one-quarter across the road (North and South) and the end of the coal is with the dip, N.E.

The main roadways are driven out to the North and South from the two shafts, and from these are driven other roadways East and West, from the far end of which coal is

INTC

Jenson F.G.S.

	Ft. In.
Roover	2.0
Scale . .	
Top Slipper	1.8
Scale . .	
White Tow	4.5
Parting	0.1
Brassils	4.4
1st Batt	0.6
Slip	1.9
Scale . .	
Stone	2.6
2nd Batt	0.6
Sawyer Slipper	4.4
Bench Batt	0.8
Bench	1.3
	24.0

Nos 3

ROOF & SIDES, Killing Wm Hodgkins.

1.

1.
N° 3

being worked back, leaving goaf or old workings behind, *as shown on the accompanying sketch plan.*

In the first openings there was a little creep or grinding of the coal, but without serious irruptions or bumping until the North roadways had been driven 300 or 400 yards from the shafts. It was then, where two slants were being commenced in a North-easterly direction, at about 630 yards below the surface, the earth shock referred to took place. It nearly filled that part of the driving with small coal or slack, jammed a loaded tub and air pipes against the roof, filled the air with inflammable gas, making great commotion and injuring three men.

With the view of avoiding a recurrence, *what is here called No. 1, shown in the accompanying drawing,* was tried, by working on the top of the Sawyer layer of coal, with an additional precaution of removing coal from each side of the driving and filling the space with chocks of wood for support. The endeavour, however, proved unavailing. The floor blew up, killing a man named William Wall and injuring several other persons, but leaving the timber couplings and the chocks unbroken.

A driving, *here called No. 2,* 400 yards away from any wide work, was then tried a little higher in the seam, coupled timber being used as before, but without side chocks. The floor for a distance of 20 yards from the face of work suddenly heaved up, but, as before, left the couplings unbroken. Some men were seriously injured, and a tub thrown up against the roof cut two inches into a cross bar. Three shifts of men were then being worked in each 24 hours.

A conference was then held with the deputies and the miners, at which it was decided to work only two shifts, and to drive the roadway nearly at the bottom of the seam,

leaving only the Benches layer of coal below, in the hope that this layer and the fireclay underneath it would not blow up as the coal had done in the previous drivings near the middle of the seam.

This driving, *called No. 3*, on the Benches layer, and working two shifts, with timber couplings only 18 inches apart, proved unsuccessful. The coal above, up to the Tow and White coal, suddenly burst down, breaking the bars into pieces.

The miners being still of opinion that it was safest for them with the driving near the bottom of the seam the place was reopened, and the timber laced together on the top, with 4-inch lagging poles, overlaid with strong oak slabs. The result, *called here No. 4*, was that after driving a few yards in the solid a terrible shock burst down the overlying coal, and drove out solid coal from six feet beyond the face of the driving, the coal being reduced to fine slack. Three men were fastened underneath, two of whom were got out, but whilst endeavouring to rescue the other, named Richards, another bump occurred, which completely filled the place with *débris*. As soon as the place became still, digging was recommenced, and was followed by a third bump, which shook the place, and slightly injured the under manager, a miner, and the author of this paper. Afterwards the dead body of Richards was found covered with slack.

It was then decided to work only one shift, and to try the effect of driving in the top of the seam. Accordingly a driving, No. 5, was made in the Roover, Top Slipper, and White coal. The result was that from over the full width of the driving the roof from a height of 10 feet burst down, and the coal at the sides and underneath the driving broke, and ignited from spontaneous combustion. After this the driving in the top part of the seam was abandoned.

Trials, No. 6, were then made by holing with a picker, 12 feet long, on the top of the Brassils coal, then taking down the Tow coal and removing the underlying part of the Brassils coal. In doing this it was soon found that, on getting two or three feet in with the holing, broken coal became thrown out in dangerous quantities, injuring one man. After this, in another road, on November 3rd, 1896, with the underlying Batt taken up and the floor of the driving in the Slip coal, suddenly the coal above burst down, and the sides of the roadway burst off for a length of about 24 feet, enlarging the width in the central portion to nearly double the original size. In this, the latest irruption, one man, named William Hodgkins, was killed and another injured.

Besides the expedients mentioned, of driving in various parts of the seam, working quickly, medium, and slowly, careful timbering and watching, boring in advance and making holes in the floor have been tried. Blasting has at most times been avoided, lest it might shake the ground, but that has been varied occasionally with a shot, especially in ground found precursory of bumps, such as at a "hard spang" among free-cutting coal and such like; but as yet without much, if any, useful effect on avoiding irruptions.

The author has observed that the worst bumps occur when driving across the grain of the coal; also that but few occur in wide work, where there is large enough area for the floor to heave, the usual height of heaving being five to six feet. He thinks that although gas may help a little, it is not the main moving cause, there having been as many irruptions without as with gas; the ground also is porous with a natural and constant oozing of gas, and the pressure of the gas tested in a borehole made 10 feet into solid coal in a gateroad 700 yards away from main workings was not sufficient to force out a plug of clay. He has read Mr.

Dickinson's official report on similar outbursts in the Nook pit, at Broad Oak Colliery, Ashton-under-Lyne, and after 20 years' experience in the South Staffordshire "thick coal," he is fully of opinion that the bumps described are due to some of the layers being too soft to withstand the pressure, certain layers of the seam sometimes yielding 70 per cent of slack.

Mr. John Ridyard said: I have much pleasure in moving a vote of thanks to the author of the paper. My experience of the thick coal seams of South Staffordshire is very small. I was once in one of those seams, and I was somewhat alarmed owing to the use of naked lights and what I thought the risk of explosions. I was told that gas had never been seen, but instances have been given in the paper showing that it is liable to occur, though the irruptions described may not be caused by it. Caution should be exercised in working these thick seams with naked lights.

The vote of thanks was seconded by Mr. George Peace, and carried unanimously.

The President, having invited discussion,

Mr. Dickinson said: The description given by Mr. Meachem in his paper affords striking evidence of exceptional difficulties attending deep mining where the coal and adjacent strata are not sufficiently hard to withstand the weight of the overlying strata. It appears that firedamp occasionally issues with the irruptions, but ordinarily it does not appear to have much influence, and from the test given of its small pressure Mr. Meachem's conclusion appears correct that it is not an important factor. There is, however, the peculiarity that the seam is very liable to

spontaneous combustion. The depth, 620 yards, at which they occur having been attained at once by sinking, and not by gradual driving down to the dip, does not afford opportunity of deciding at what depth they would have begun. The local name for the occurrences is "Bumps." That is an old name for what used often to occur in the comparatively shallow mines in the Thick Coal. I have heard such occur with a dull thud, and have seen large quantities of coal thrown off without the labour of working, and attended with serious consequences to the persons exposed. The occurrences are of the same kind as those described in my paper read before this Society in 1893 (Trans. Part VIII., Vol. XXII.,) on "Outbursts of Coal at the Nook Pits, Ashton-under-Lyne." In both collieries the coal is liable to spontaneous combustion, and the irruptions issued with a loud noise without previous warning; and in both boring in advance with variety of driving had been tried without producing much, if any, useful effect. The chief differences between the two are: At Nook the seam is thin, with a very steep dip, and yields firedamp abundantly; whilst the Staffordshire seam is thick, with very little dip, and gives off but little firedamp. In the Nook Pit also the depth at which the pressure became injuriously exerted admitted of being fixed at 500 yards below the surface, the commencement being when the down-brow workings attained that depth. With regard to the system of working in this South Staffordshire colliery, a first glance at the plan which accompanies the paper illustrating the system of working may be considered wasteful, there being large pillars and ribs left unworked, with the uncertainty whether at this depth they can ever be reopened and worked as extensively done in the shallow thick coal. But the main feature of the ribs is the control afforded of being able, by putting in only two stoppings, to

shut off any part ignited by spontaneous combustion, leaving the other parts of the mine available for work. In this respect the device is masterly, and reminds me of what was done early in the present century by the eminent miner, Mr. John Buddle, of Wallsend, who, to guard against excessive firedamp, originated the panel system, by which any panel could be separated from the other panels, with an outlet for gas under pressure into a gas return separate from the return airway.

The PRESIDENT called attention to the presence in the meeting of Miss Maiden, the proprietor of the Broad Oak Colliery, Ashton, and of her manager, Mr. Arthur Miller. Perhaps Mr. Miller would be good enough to state what steps had been taken to avoid accidents.

Mr. MILLER said: I have listened with great interest to the paper, having had the management for over two years of the mine at Ashton referred to by Mr. Dickinson. The statement of what has occurred in Staffordshire has come upon us rather suddenly, because we were under the impression that no one was troubled to anything like the same extent as ourselves. Others, it appears, suffer, though not exactly under the same conditions, and if they have spontaneous combustion to contend with, in addition to outbursts or "bumps," they have certainly enough to do. Of course, in our case, when an outburst occurred, we had not the alternative of trying another layer. Our coal is just under two feet thick, and what we call the minings—the soft part overlying,—about half a yard. It was impossible to hole in the coal; the stuff above being so soft, we could not support it; so we had no alternative except to hole in this soft stuff. It seems rather strange that, in Staffordshire, they should have the outbursts, and yet no great quantity of gas be given off. I may be wrong—Miss Maiden will

correct me if I am—but I believe that in all the outbursts at Broad Oak there have been great quantities of gas.

Miss MAIDEN: No; in some gas has been almost entirely absent. In some there has been no sign of gas from the bore hole, or there has been so little gas after an irruption that the lamps have not been put out.

Mr. MILLER: I am speaking now of the large outbursts.

Miss MAIDEN: In the large outbursts unfortunately no one was left to describe what took place.

Mr. MILLER: I cannot, of course, speak from personal knowledge, not having been at the time connected with the colliery.

Miss MAIDEN: In some of the outbursts where fatality has occurred there was not a very great amount of gas, although our mine gives off, naturally, a large quantity.

The PRESIDENT: Have you utilised that gas in any way? I suppose you would be only too glad to get rid of it.

Miss MAIDEN: The only way we can deal with it is to pass it into the return air course, and get rid of it as quickly as possible.

Mr. MILLER asked if the coal, in the case of the Staffordshire colliery, was not much harder in substance than that at Broad Oak?

Mr. DICKINSON: The sections show which of the layers are hard and which are soft. Many of them are very soft.

Miss MAIDEN: As soft as ours, Mr. Dickinson?

Mr. DICKINSON: I should think about the same. You may fancy they are soft coal from the concluding part of the paper, where Mr. Meachem says that they yield 70 per cent. of slack.

Miss MAIDEN: In that they are on all fours with us; but in our case we have a hard floor and a hard roof.

Mr. DICKINSON: They have both a soft floor and a soft roof.

Miss MAIDEN: What width of works are they driving?

Mr. DICKINSON: The roadways are 9 ft. wide at the bottom, supported by double timbers or couplings 7 ft. high, with 6 ft. cross bars at the top.

Miss MAIDEN: Perhaps you are aware that we have been driving wide work?

Mr. DICKINSON: I know that you have been driving both wide and narrow work, and outbursts, I believe, have taken place in both.

Miss MAIDEN: We have been driving wide work lately, taking all out as we go in, and we have not had an outburst since we began.

Mr. MILLER: May I ask if there have been any outbursts at other pits in the Staffordshire district?

Mr. DICKINSON: I am not prepared to answer that question, but I should think it is quite possible. There is Sandwell Park, the adjoining colliery, at a similar depth; they may have had experience of the kind, I don't know. But I may tell you what came under my own knowledge in the shallower workings when that was a part of my district. These bumps took place at comparatively shallow depths, and they threw off as much coal as served to keep the ropes of the pit busily going the whole day without any trouble with the pick.

Mr. MILLER: We are at present working wide work. In the leading places we never drive less than 15 yards wide, except, of course, where we have to cross a fault, and in them we keep three bore holes—one in the centre, one on the higher, and one on the lower side. We put these bore holes in ten feet ahead, and when four or five feet of the coal has been worked off we put

other bore holes in. With this system we have had no outburst since I have been at the place, nor for some months previously. We have opened out a new work since I went, and have taken the whole of the coal out there too.

Mr. PEACE: Is gas given off from the bore-holes?

Mr. MILLER: Sometimes; sometimes we put the bore-holes in without finding a trace of gas; at other times we come across a lot of very soft "minings," which occasionally gives off a large quantity of gas. It varies to a very large extent.

Mr. W. WATTS: I would like to offer one or two observations upon this valuable paper, and would compliment the author on the most admirable diagrams with which it is illustrated. I hope they will appear in the Society's Transactions. The "bumps" are, I presume, what are called in some geological works "creeps," and I am astonished that they should take place at such a depth below the surface, and be so pronounced as would appear from the diagrams. It does seem to me, as an outsider, most singular that these creeps should be attributed to the presence of gas in the coal. My notion is that they are due absolutely to the vertical pressure exerting itself upon the soft material in which the workings take place. It is remarkable, however, to find that when you widen the openings or the headways (whatever name you give them), these bumps practically cease. That is the most singular feature of the case, and I wondered, as I listened to the last speaker, whether or not there was any change in the character of the material in which these headways are made. The bumps take place in the coal, not in the seating underneath it.

Mr. DICKINSON: In both in Staffordshire.

Mr. WATTS: I am referring to Section No. 1, particularly showing the uprising. You find a similar thing taking

place in deep trenches, where you have a soft material as shown in the section; but you never find these bumps or creeps taking place where the material is hard. It struck me if this kind of behaviour takes place in a deep puddle trench you need not be surprised at its occurring in the soft coal. I have work on hand now, under the direction of Mr. Hill, C.E., where we have a precisely similar thing taking place at 109 feet below the surface, but in the soft ground only. We have no gas there, so it strikes me very forcibly that although gas may be present in large quantities in the coal—in the roof, sides, and all round—it has nothing whatever to do with the uprising of the floor, or even the depression of the roof. These are the main points, Mr. President, which I wished to mention. I speak, of course, not as a mining expert, but as an outsider.

Mr. Watts gave a diagram on the blackboard of work on which he is now engaged in illustration of the preceding remarks. The work is at a reservoir which is being constructed for the Oldham Corporation. The floor, he said, rises up, and in some cases it has actually pushed up the "stretchers," solid pieces of timber 11 feet in length and 10 inches square, and broken them, showing that the pressure from below must be very considerable. They were troubled with it, not only from below, but also laterally, though not to the same extent, and the greatest difficulty they had to deal with arose from the upward pressure. The uprising would sometimes be as much as six inches between the time the men left work at night and their resuming next morning. The stretchers were placed 18 inches apart vertically and from four to six feet horizontally. In some cases the ends of the stretchers were forced through a 3-inch upright and 3-inch wailings respectively.

REMARKS ON SOME INTERESTING COAL MEASURE SECTIONS IN THE LEICESTERSHIRE AND SOUTH DERBYSHIRE COALFIELD.

By Mr. W. S. Gresley, F.G.S., F.G.S.A.

The extreme north-west corner of Leicestershire contains the major portion of the exposed Moira, a western division of the Ashby-de-la-Zouch coalfield, the lesser portion lying to the north in Derbyshire. In both these districts, and especially along the border line of these two counties, namely, upon Ashby Wolds and Gresley Common, the well known beds of fireclay are extensively worked, both by mining and quarrying (open holes). These open holes are very numerous, and being in many cases quite deep, they expose excellent sections of the fireclay series, some of which are 50 or 60 ft. thick, including the "bearing."* The geologic horizon of the principal stratum of fireclay (see bed No. 7, Fig. 1) is about 855 ft. above the "main coal" seam. The topography is rather hilly, varying from 375 to 450 feet above sea level.

In 1887 the writer, during his investigations in the district, came upon the peculiar disturbance in the fireclay measures, as exposed in a vertical cut, shown in Fig. 1. The precise locality of this "fault" is one-third of a mile south of the reservoir in N.W. corner of ¼-sheet "No. LXIII. N.W." of the 1 in. coloured Geological Ordnance Survey. The elevation here would be about 420 feet above sea level. The open hole is on the north slope of a westerly spur of higher ground, about one mile to the east. About 110 ft. N.W. of section Fig. 1, namely, in the opposite side of the excavation, a second and very similar break in the coal and

* Bearing is the worthless material on top of the clay beds, for the most part shales and nodules.

underlying clay beds was revealed, but the cut or furrow was not quite so deep. As the intervening strata between these two exposures had all been dug away, and rubbish thrown back into the space, the natural inference is that the furrow passed clear across the open hole, and ran approximately N.W. and S.E. for a considerable distance on either side of the pit, being concealed by the soil and grass of the field in which the pit was.

About 1,000 feet in a S.E. line from section Fig. 1, another clay pit (just over the brow of the hill) revealed the plication of strata shown in Fig. 2. This ran across the open hole for several yards, when the descending surface cut it out. In the absence of any exposure of beds between Figs. 1 and 2 (up to 1889, when the author left the neighbourhood for America), the connection between the furrow Fig. 1 and the twist Fig. 2, is left to conjecture. The two things may or may not be really one and the same in changed forms, just as an upthrow fault may become a downthrow as traced horizontally. Contorted beds are not common in this district. The author considers the furrow in Fig. 1 affords material for some discussion as to its meaning or origin. We naturally ask :—

1. Was this gash or furrow ever deeper than now, *i.e.*, at the time it was made were there any more strata above that thin bed of coal "3," and if so, what thickness?

2. When or at what period was the cut made? viz., during the Coal Measure age, or in some subsequent period!

3. Can the phenomenon be paralleled or interpreted by any very similar thing whose origin is evident?

Replying to these questions, it may in the first place be remarked that the disturbance is not due to local upheaval nor of the nature of a fissure or rent, neither was it produced by lateral stretch. This is evident from the normal or undisturbed position of the strata in the rest of

the exposures, and from the immediate surroundings of the cleft or gash itself, namely, the plicated, thrust aside, and afterward partial closure again of the severed beds of clay (4, 5, 6, 7 of Fig. 1). The very character and kind of infilling of the gash disagrees with an upthrust or side-pull origin. Clearly this groove was once *wider* towards the bottom than it is to-day. Secondly, the presence of *sand* in the gash, as none exists in the strata of the clay pits, shows that it came from some bed of sandstone, now denuded, or it is sand transported from a distance. When these open holes and pits are deep enough to expose more of the overlying beds, a stratum of coarsish sandstone occurs about 16 feet above the coal bed (3). We must therefore suppose the gash was at least 16 feet deeper than now if the included sand (x) belongs to the above sandstone; in which case a vertical thickness of 16 feet of shales and bands of clay-ironstone must have been involved in the rent, which would be at least 21 feet deep at this spot. But there was nothing particular in this sand to identify it with others. About the only peculiar feature of it was that the grains were a good deal blackened, apparently by long contact with the coal mixing up with it.

As to answering question 2, several things are clear. The fault is younger than the beds it occurs in and older than the soil overlying the entire district. It cannot be an artificial cut—the site of tree roots, animal burrowing, or even an ancient watercourse. The filling of the channel evidently closely followed the cutting of it open. If the channel were formed during the deposition of the Coal Measure strata, whatever it was that made it was powerful enough to tear its way through at least 21 feet of vertical sediments, as already pointed out, more or less consolidated into rocks as we have them now.

Have any such gash-like disturbances been met with or

recorded in Coal Measures which must have been contemporaneous with those measures? The nearest resemblance to such a thing the author has noticed, and scrutinised is given in Fig. 3. My interpretation of Fig. 3 would be that the gashes or channels X and X' were produced very soon after the seam of coal was completed by snags dragged over the submerged area, tearing out the coaly material, and producing grooves that were at once filled by fragments of shale and coal bordering, and disturbed by the passage of the snags on their down-stream course. That these roughly parallel channels may possibly owe their origin to small icebergs floating over the carboniferous water-wastes the author for one admits, and will refer in this connection to Mr. James Radcliffe's interesting paper.*

But the gash (Fig. 1) may possibly date from the general erosion or denudation following the coal period, or during the Permo-carboniferous *interval;* or, perhaps, its age is that of the time when the Middle Coal Measures of the Ashby coalfield became largely denuded prior to the deposition of the Upper Coal Measure series.† Another period we might assign it to is that of the Permian breccias of this region, whose huge transported boulders‡ attest to a turmoil of waters and local violence operating in this locality. As these breccias occur in many places within a few miles of the *locus in quo,* we might, with show of reason, date this furrow back to Permian time, and view the enveloped sand (X Fig. 1) as belonging to that epoch, supposing it to have been dislodged from the iceberg that perhaps made the furrow. But even if this particular pocket, or strip of sand, were really Permian sand, there will still remain

* Q.J.G.S., Vol. XLIII., p. 599.

† Mem. Geol. Surv. (Leicestershire Coalfield), by E. Hull, 1860, p 56.

‡ "Midland Naturalist," Vol. XV., p. 25.

doubt as to *when* it was introduced, not necessarily in Permian time, for the neighbourhood has contained plenty of that sand ever since that age. We may, I think presume, that the furrow was cut at a time when the strata 2, 3, 4, &c., (Fig. 1) were bare, or only covered by water, and, perhaps, some sand.

The district in which these open holes abound is anything but a sandy one, and excepting a little sand made by weathering of an exposure of Upper Coal Measure grit about half a mile S.E. of section Fig. 1, there is no surface exposure of sand or sandstone nearer than a Triassic outcrop at Boothorpe, 1¼ miles east of the furrow.

If we refuse to accept the Permian or Coal Measure age of the gash, it would seem that we must come down to a period when all the Secondary and (?) Tertiary strata (if any) had been denuded from the locality—to perhaps the Pleistocene age.

Fig. 4 illustrates a rather peculiar severance or cut occurring in the thick "bearing" of an open hole on Gresley Common. It might be regarded as a small or local overlap or reverse fault, but inasmuch as the measures immediately underlying it were in quite normal, *i.e.*, in an undisturbed condition, the inference is that the cut was made from the surface, and closed up tight as soon as made without (just *here* at all events) any extraneous materials getting into it. No further exposure of this disturbance was made, because the clays here became too deep to follow by open workings, and mining by shafts was resorted to.

In Fig. 5 we see a rather startling jumble of coal and associated shales, &c., close to the surface, at about one mile S.E. of Fig. 4, and 1½ miles N.N.E. of Fig. 1. Unfortunately the author saw nothing of this contortion until the cutting was almost completed and the slopes formed. The

section, however, seems to suggest some local and powerful agent having operated in a plowing or raking fashion at some remote period—perhaps Pleistocene ice age.

Now, while we possess no evidence to show at what geologic period any one of the irregularities shown in Figs. 1, 2, 4, and 5 were produced, the occurrence of several somewhat similar disturbances near the surface, and the apparent paucity of them in depth (in coal mines), so far as my observations have gone, seem almost to warrant the conclusion that the gash in Fig. 1 was probably not made in the coal period, nor yet in Permian age, but most likely about the time of the so-called glacial period or Great Ice Age, namely, when bergs or blocks of floating ice were drifted across the then submerged region, many of which doubtless carried rock debris. Granting this much, or at any rate that these strata were ripped across by icebergs at some period before the soil was formed, it would be interesting (were we able to trace it), in which directions the ice blocks travelled. If the facts regarding Fig. 1 can be taken as good evidence in this connection, the probabilities are that the gash was plowed up from N.W. to S.E., and we should expect to find the furrow get deeper or more pronounced as the surface rose in a S.E. direction. Possibly extended excavations (since 1887) have revealed something interesting herein, and local geologists (if any) might with profit visit the place.*

The author, after 25 years' study of faults, &c., in the Coal Measures, both above as well as underground, is of opinion that such disturbances as local "rolls," "saddles," twists and jumbles, occur very frequently at and near the surface, and that their formation is principally due to the stirring up or disruption of the uppermost strata by ice-

* That the furrow was more than 6½ feet deep originally may be granted, when it is remembered that surface erosion since the (?) glacial period probably amounted to a foot or more.

plows or rams of enormous power, the observed phenomena seem to point.*

In conclusion, the facts adduced herein testify to a period of submergence of this part of the Midlands, *since* the Ashby coalfield was, geologically, about as we find it now.

Apropos to this supposed evidence of a glacial period on Ashby Wolds, probably a brief reference to the discovery in 1866 of a curious relic of (?) "the ice-age" *in a coal bed* on Gresley Common may be of interest. This relic was a rude mass of *genuine oak* (very hard and nearly black in colour), completely embedded in the middle of the "Bourne's" (or "Ell") coal seam, overlying a bed of pot-clay, the working of which clay and necessary removal of the coal led to the discovery of the piece of wood. Mr. H. L. Ensor, to whom I am indebted for details of this find, and who worked this clay pit, informed me that the oak was about 6½ feet in length and about 2 feet diameter in middle, but roughly the shape of a weaver's shuttle, being rather hollow. Mr. Ensor presented me with a piece of the oak some years after it was dug out. Excepting for the bending of the layers of coal over the piece of wood the seam lay in its normal condition, and was covered by about six or eight feet of shales and surface clays. This coal seam is a very well recognised one in the district, and its position in the series is about 50 feet beneath the coal bed seen in Figs. 1 and 2. The site of this piece of oak would be about two miles north of the furrow, Fig. 1.

Now, the only way in which a piece of *oak* could get into a bed of coal of carboniferous age, would seem to be through the agency of ice. And I see no valid reason why a grounded mass of ice should not shove a drifted or sunken snag of an oak tree, such as this, into an outcrop of a bed

* The author's note books teem with instances of surface jumbles observed in the Leicestershire and Derbyshire coalfields.

of coal, where it would subsequently be completely entombed by mud, clay, &c. I refer to this fact, because I think the explanation of it is in line with that of the furrow, illustrated in Fig. 1; in other words, that both are probably attributable to a large mass of floating ice, pushing or scraping on the bottom of a lake.

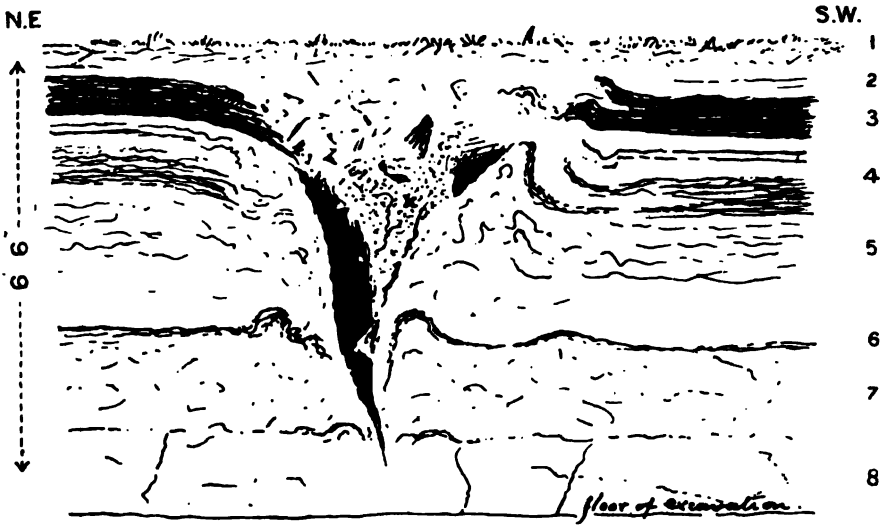


FIG. 1.

VERTICAL SECTION IN A CLAY-PIT ON ASHBY WOLDS, EXHIBITING A DEEP GROOVE OR FURROW. April, 1887.

1. Surface soil.
2. Yellow clay; probably altered blue shale normally overlying coal bed (3).
3. Coal-seam; very persistent horizon in the district.
4. Alternate layers of black and dark-blue shale, crumpled adjacent to the furrow.
5. Fire clay; called "the marl," cut through by the coal and sand-filled groove.
6. Thin layer of dark-grey fire clay, contorted on either side of the intrusion of coal (3).
7. Fire clay; good, completely severed by intrusion of coal (3).
8. Fire clay; inferior, as far as into which the broken coalbed (3) had been forced.

× Yellowish sand incorporated in the disturbed mass of coal, &c.

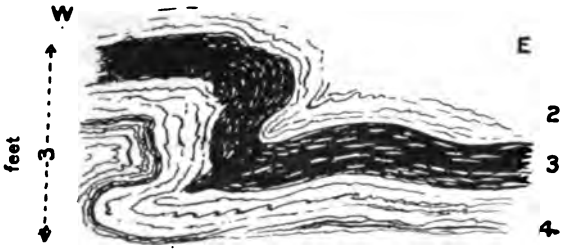


FIG. 2.

VERTICAL SECTION IN HEYWOOD'S FIRE-CLAY PIT,
ABOUT 1000 FEET S.E. OF SECTION FIG. 1. September, 1887.

NOTE.—The figures numbering the beds correspond to same beds seen in Fig. 1.

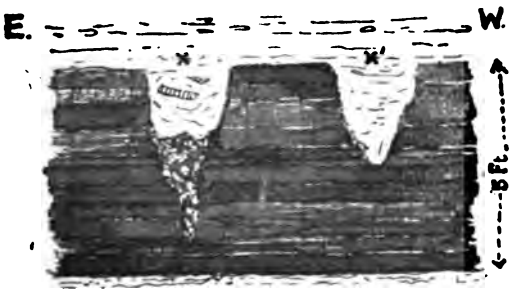


FIG. 3.

VERTICAL SECTION OF THE "FIVE-FOOT" COAL SEAM,
AT ABOUT 780 FEET DEEP, IN THE CHURCH GRESLEY COLLIERY.
August, 1887.

Partially intersected vertically by two grooves, X X', 5 feet apart. Lower part of X filled with crushed coal and hard clay; upper part and X' with same material (shale) as the ordinary roof of the coal-seam.

FIG. 4.

VERTICAL SECTION OF BLUE SHALE,

WITH A 7-INCH BAND OF CLAY-IRONSTONE, AS SEEN IN THE "BEARING" IN A CLAY PIT ON GRESLEY COMMON, ABOUT 5 FEET BELOW THE SOIL.

October, 1886.

NOTE.—The erratic piece of ironstone × appeared to have been dragged downwards from ×′ at the time when the cut, on which it lay, was made.

Scale, 10 feet = 1 inch.

FIG. 5.

SECTION, SLOPING 1½ TO 1, OF HIGHLY DISTURBED COAL SEAMS IN A CUTTING ON MIDLAND RAILWAY AT LITTLEWORTH, ON ASHBY WOLDS.

October, 1879.

On the motion of the PRESIDENT, seconded by Mr. HALL, the thanks of the meeting were voted to Mr. Gresley for his paper.

REPORT OF THE DELEGATE TO THE MEETING OF THE BRITISH ASSOCIATION AT LIVERPOOL, SEPTEMBER, 1896.

BY MR. MARK STIRRUP, F.G.S.

As the members are aware, our Society is affiliated to the British Association as one of its Corresponding Societies, and in the capacity of your delegate I attended the meeting of the Association, which opened in Liverpool on the 16th of September last.

Under these circumstances it becomes my duty to bring before you some details of the subjects brought up for discussion at the two conferences of the delegates of the societies which were held during the week of the Association meeting.

I may state in the first place that a larger number of delegates than is usual at these meetings was present at Liverpool, and that these gentlemen represented forty-nine societies, whose sphere of work and influence embraced almost all parts of the United Kingdom, including the Isle of Man.

Two conferences of the delegates are as a rule fixed to take place during the British Association week, at each of which the delegates are strongly enjoined by the Committee to be present, so that they may be able to convey to the Society they represent, a faithful report of the proceedings.

In place of the former somewhat desultory conversation at these meetings upon various matters connected with the

work and organization of local societies, it has for the last two or three years been thought more useful to have some special subject appointed for discussion at the conferences.

In this way the subject of Local Museums and their management was introduced by Mr. Cuthbert Peek at the Oxford meeting in 1894, and last year at Ipswich Mr. G. J. Symons made some remarks on Meteorological Observations and the value of records of Sea and River Temperatures, as well as of underground or earth temperatures.

In the continuance of this line of procedure at the recent Liverpool meeting Dr. George Abbott gave an address on "District Unions of Natural History Societies," copies of the address being handed round to the delegates.

While granting that many of these local societies had done and were still doing good work, Dr. Abbott said the efforts of others had failed, owing to the want of better organisation and a recognized plan of systematised work. He advocated a plan of dividing the United Kingdom into fifteen or twenty districts, in each of which all the existing Natural History Societies should be affiliated for mutual aid, counsel, and work. Each of these district unions would have its annual congress.

"These unions," Dr. Abbott says, "would render important help to local societies, would bring isolated workers together, assist schools, colleges, and technical institutes and museums, start new societies, and revive waning ones."

In the discussion which followed the reading of the address, the Rev. E. P. Knubley remarked on the success which had attended the Yorkshire Naturalists' Union during the 20 years of its existence. The Union consisted of 36 affiliated Associations, numbering 500 members and 2,500 associates.

Its scientific work was apportioned to five sections—

geology, botany, zoology, conchology, and entomology, each of which had its separate officers.

After remarks from other delegates, a sub-committee was nominated to consider the question, and report to a future conference.

At the Second Conference, held on the 22nd September, Professor Flinders Petrie read a paper "On a Federal Staff for Local Museums," in which he suggested co-operation in the management of those country museums, which otherwise were unable, owing to deficiency of funds, to provide the skilled assistance necessary for keeping them up to modern requirements.

"In all local museums, Professor Petrie remarks, the main difficulty of the management is, that there is neither money nor work enough for a highly trained and competent man. It is in any case impossible to get a universal genius who can deal with every class of object equally well, and hardly any local museum can afford to pay for a first-class curator on any one subject. These difficulties are entirely the result of a want of co-operation."

The practical course, Professor Petrie suggests, would be the union of a number of museums, which would thus be able to pay the expenses of providing what he calls a "federal staff," to circulate for all purposes requiring skilled knowledge, leaving the permanent attention to each place to devolve on a mere caretaker.

This visiting staff of specialists, in the course of their regular round, would be able to name new specimens, advise on alterations and improvements in the museum, give occasional lectures, and otherwise exert a beneficial influence upon the management of the museum, and the neighbourhood interested in its success.

After a discussion of the paper, reports of the work undertaken by the different Corresponding Societies were submitted.

Mr. W. W. Watts, representing the Geological Photographs Committee (one of the Committees appointed by the British Association for the investigation of special objects of scientific interest), said that although some of the Committees nominated by Section C had come to an end, yet the Geological Photographs Committee was still in existence, and recommended its work, as well as that of the Erratic Blocks Committee, to the attention of the local societies.

Since the meeting at Liverpool the Secretary of the Geological Photographs Committee has issued a circular urging the active co-operation of the societies in obtaining photographs of geological interest in their respective districts. This Committee has now been in existence about seven years, and a large collection of photographs, illustrating the geology of the country has been formed, but there are still large areas unrepresented. This collection has been deposited at the Museum of Practical Geology, 28, Jermyn Street, London, and is accessible to the public for purposes of reference.

These photographs illustrate characteristic geological phenomena of all kinds, as well as those of microscopical sections of rocks and typical fossils.

Instructions and hints as to the best sort of camera to be used, size of the photos, and other information is given in the circular, particulars of which I shall be glad to place in the hands of any member who is willing to take up work of this kind.

Mr. De Rance followed, and referred to the work of the Underground Waters Committee, which, though it had ceased to exist, he hoped the delegates of the Corresponding

Societies would urge on their members to record carefully in their districts everything bearing on the subject, not only the geological nature of the strata, but also the temperature of the water obtained from great depths.

Mr. Sidney Hartland, Secretary of the Ethnographical Survey Committee, in addressing the delegates, asked for the co-operation of the local societies in the work of his Committee, whose object is to obtain a collection of authentic information relative to the population of the British islands, with a view to determine, as far as possible, the racial elements of which it is composed.

The Committee's inquiries are classed under five heads, as follow :—

1. Physical types of the inhabitants.
2. Current traditions and beliefs.
3. Peculiarities of dialect.
4. Monuments and other remains of ancient culture.
5. Historical evidence as to continuity of race.

After some remarks on the subject by one of the delegates and the Chairman, the meeting was brought to a close and adjourned.

I have in previous reports, in addition to the main object of my mission as representative of our Society at the meetings of the Corresponding Societies, drawn attention to papers brought before the Geological Section having local or special interest. In this category Professor Dawkins' address on the "Geology of the Isle of Man" may be named, the principal points of which it may be useful to summarise.

The main mass of what may be called the foundation rocks of the island consists of clay-slates, phyllites, and quartzites of Cambro-Silurian (Ordovician) age, much folded and contorted, traversed in places by numerous

volcanic dykes, and penetrated at Foxdale and elsewhere by bosses of granite.

These rocks are, as a rule, unfossiliferous, the slates and shales forming the central nucleus of the hills Snaefel, North and South Barule, &c., while the quartzites, for the most part, occupy the littoral areas.

In the south of the island, near Castletown, a series of Carboniferous Limestone beds is seen resting on highly contorted Ordovician rocks, the limestone in places being traversed by numerous volcanic dykes of great interest. In the north, in the neighbourhood of Peel, the Red Sandstones and Conglomerates, which form so prominent a feature of the district, have been identified as belonging to the Permian Formation, and not to the Old Red Sandstone, as was formerly thought to be the case.

The large area of the northern part of the island, forming a flat expanse thickly covered by glacial drift, has recently been penetrated by several borings in search of coal, which have been the means of disclosing the nature of the underlying rocks.

The Glacial Drift in two of these boreholes amounted to upwards of 170 feet, while in another, at the Point of Ayre, no less a thickness than 298 feet of drift sands, gravels, and clays were passed through, reaching the Triassic Sandstone, and passing ultimately into the Carboniferous Limestone. No coal seam, however, has been found, although a depth of 961 feet was reached.

The discovery of a saltfield, however, was the result, a fact of much geological interest. The Salt Rock was reached at 500 feet below the surface in the Trias. Details of the borings and other information will be found in Professor Dawkins' paper.

Another paper of interest to Manchester geologists is that of Mr. H. C. Beasley, on "Footprints from the Trias in the neighbourhood of Liverpool."

Besides the well-known footprints of the reptilian Cheirotherium, Mr. Beasley drew attention to a number of other and smaller footprints found in the same strata. These differ so much in character as to warrant him in asserting that they belong to quite distinct forms, which he has arranged under numbers rather than names. The prints indicate, Mr. Beasley says, animals of terrestrial and not marine habits. Slabs of the sandstone bearing these various forms may be seen at the Bootle and Liverpool Museums.

Mr. G. H. Morton, of the Liverpool Geological Society, and an honorary member of our own, in one of the papers he brought before the Association, drew attention to the erosion of the sea coast of Wirral, that length of shore and sand dunes on the Cheshire side of the Mersey, stretching from beyond New Brighton as far as Hoylake. That the sea has made great inroads upon the land, and is still doing so, is made evident even to the casual visitor by the undercutting of the sand dunes in places, the remains of a submerged forest at Leasowe, and the erection of artificial embankments and groins to resist further encroachment. How long this has been going on there are no documents to prove, as the oldest existing maps are unreliable as to the exact outline of the coast at the time when these old maps were published. Mr. Morton has had for many years past this portion of the coast under his personal observation, and from measurements which he has made, states that the rate of erosion, though varying from year to year, may be estimated at four to five yards per annum during the period of the last 30 years. The greatest loss of land takes place at Dove Point, whereas in front of Hoylake no erosion is going

on; probably Hilbre Island protects this part of the coast from waste.

If the time at my disposal had permitted, I might have referred to other important papers brought before Section C of perhaps wider and more general interest, but have restricted myself to the foregoing sketch of a few papers having local interest to Lancashire geologists.

On the motion of Mr. DICKINSON, seconded by Mr. HALL, the thanks of the meeting were given to the President for his report.

BORING FOR COAL AT BOLD, NEAR ST. HELENS.

Mr. HALL said: I wish to mention that, if the members think it would be of interest to them, I could arrange for a visit to the Bold sinkings, which pass through the Red Sandstone which is there 180 yards thick. What strikes me as most interesting is that they have the stratification, bored out with a Beaumont drill, about 500 or 600 yards deep, preserved in Bold Hall. They have all the cores, starting at six inches down to about two inches, laid out in the different rooms, so that geologists have the opportunity of seeing a core out of the earth something like 550 yards long, through the red rock and through the uppermost seam of the St. Helens coalfield.

The PRESIDENT expressed the obligation of the Society to Mr. Hall, and the feeling of the members was in favour of making an excursion to Bold some time during the new year, the date and other arrangements to be fixed hereafter.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART IV. VOL. XXV. SESSION 1896-97.

A SPECIAL MEETING of the Members was held on Friday evening, December 18th, 1896, at the Society's Rooms, Queen's Chambers, John Dalton Street.

The President: Mr. MARK STIRRUP, F.G.S., in the Chair.

The PRESIDENT said the meeting that evening was somewhat out of the ordinary course, and it had been called by way of experiment, because it was often said that many members of the Society found it impossible to attend the ordinary meetings, which were held in the afternoon once a month. If encouragement in this new departure were given to the Council other evening meetings would be arranged. It depended very much upon the members themselves to show their appreciation of them by a large attendance. The interest in the present meeting would be supplied by two papers, which had been promised by Messrs. Barnes and Holroyd, whose collection of Carboniferous limestone fossil corals exhibited on the table was one of great interest and value. You have all (the President continued) been interested in the accounts of the earthquake which visited us yesterday morning, and which some present may have felt. It would be exceedingly interesting if any of you, gentlemen, who may be connected with coal mining, could collect information as to whether, and in what degree, the shock was felt below the surface of

the earth, and also at what depths. I should be deeply obliged if gentlemen would make inquiries of underground managers and others who may have been at work at the time whether they felt anything of the earth tremor, which was evidently felt above ground over a wide area. It would be exceedingly interesting to learn if the disturbance was felt at all in any of the deep pits in this district.

SOME EXPERIMENTS WITH REGARD TO EFFECTS OF PRESSURE UPON DECAYING VEGETABLE MATTER.

By Messrs. J. Barnes, F.G.S., and W. F. Holroyd, F.G.S.

At the suggestion of our friend, Dr. Wheelton Hind, of Stoke-upon-Trent, we have made a number of experiments to show the effects of great pressure on vegetable matter, and for this purpose we commenced by taking freshly-cut peat, and placing it in an iron cylinder, three inches deep and three inches in diameter, the walls of which were 2½ inches in thickness.

Into this receptacle we placed peat still containing water, and upon the peat an iron ram of diameter just sufficient to allow of passing smoothly into the cell. We applied pressure by means of a hydraulic pump, and before much pressure had been obtained, not more than one ton to the square inch, the iron receptacle burst. This was probably due to the great incompressibility of the water contained in the peat.

An iron band was afterwards placed around the fractured vessel, and another attempt was made upon peat which had been previously thoroughly dessicated.

The experiment did not burst off the iron band, and so the compression of the peat was allowed to proceed up to

12 tons to the square inch. This pressure was allowed to remain from 12 to 14 hours, after which the pressure was removed and the compressed peat withdrawn.

We noticed that at the periphery of the compressed mass, that is, at the part in contact with the internal surface of the iron cylinder, the external portion of the compressed peat presented a shiny blackish appearance, very much resembling coal, and that it had decreased in volume, by its compression, to about one-fifth of its original bulk.

Its general appearance when broken showed that in a great measure the fibrous vegetable structure was much reduced or destroyed, and that it had a distinctly lignitic appearance.

By calculation we found that its specific gravity was 1·5, the specific gravity of coal being from 1·2 to 1·8.

We next collected a quantity of leaves which had fallen during the late autumn, leaves of ash, sycamore, oak, elm, and hawthorn, and subjected these to pressure whilst wet. The result was similar to that in the first instance, viz., that the thick, strong wrought-iron band was forced asunder, exactly as in the case of the wet peat.

Profiting by our previous experience, we dried the leaves and placed them under a pressure of 20 tons to the square inch, with the result that after being subjected to the pressure and time previously named we found that the leaves also were very much altered, and that at the margin of the cylinder of compressed leaves the same coaly appearance was presented, and that also on the upper and lower surfaces there were small shiny particles to be seen.

The specific gravity of the compressed leaves was found to be 1·42.

We made an experiment also with sycamore shavings, and produced the compact mass of substance here exhibited.

Coaly substance was found in this case on the periphery, but the change was on the whole not so marked as where partially decomposed material was employed.

We also made another experiment with peat at a still greater pressure, and found that the change of mineralisation at the point of contact with the iron was greater than in the first experiment previously described.

The specimens are here for examination, and we think them interesting to all who have to do with coal mining.

"The compressed peat behaves itself when burnt very much in the same way as does coal.

"An ordinary piece of peat behaves more like wood, simply bursting into flame when thrown on the fire.

"Coal only begins to burn and blaze after a short length of time, and similarly the compressed peat when thrown into the fire does not ignite at once, but after a short time bursts into flame, emitting streams of volatile gases, which burn."—(Dr. Wheelton Hind.)

From these experiments it would appear that pressure must have played *one* very important part in the changes from vegetable decomposing matter to mineralised coal.

The experiments also show that it is necessary for the material to be in a decomposing condition, and also that water must be absent when coal formation takes place, water being incompressible, except to a very slight extent, and thus preventing the vegetable matter from becoming compact.

In our experiments it was found to be impossible to form a compact mass while the water was present, but on its removal by drying the consolidation was much facilitated.

The PRESIDENT invited discussion upon the paper. It would appear, he observed, as if Messrs. Barnes and Holroyd were trying to make coal artificially from decomposing vegetable matter. Whether that is what they wish to do I cannot tell; at any rate I do not think they will frighten the coalowners.

Mr. BARNES: Certainly not.

The PRESIDENT: Still the results are sufficiently curious. With regard to the shining particles on the compressed peat, I would like to ask whether it is certain they were the the result of the pressure and were not rather of extraneous origin.

Mr. BARNES: It is extremely improbable they could have been introduced accidentally; certainly not among the sycamore shavings.

The PRESIDENT: Do you find the same in all?

Mr. BARNES: We do, but more in the case of the leaves than in the others.

The PRESIDENT: We understand, of course, that coal has been produced by the mineralisation of vegetable matter, but I can scarcely see how the time mentioned (14 hours) can have sufficed for these leaves and other things to have undergone any mineralising process.

Mr. BARNES: You have it shown in the specimens.

The PRESIDENT: But that mineral matter may have been introduced with the leaves.

Mr. BARNES: The leaves were perfectly clean.

The PRESIDENT: Notice was taken of that fact?

Mr. BARNES: Oh yes; and there was certainly no signs of any coal in this peat. It was cut on the top of Pule Hill. The iron cylinders, moreover, were perfectly clean, and specially turned for the purpose.

Mr. Scowcroft: Does Mr. Barnes support the theory that no coal was formed under water? He seemed to make a point that water must be absent.

Mr. Barnes: Yes, it would appear that water must be absent before you can get the material compressed sufficiently. Our experiments showed that in a moist state it could not be got close enough together for the particles to cohere.

Mr. Scowcroft: To my mind that opens up an interesting subject for discussion. I scarcely feel capable to-night of entering into it, but I trust opportunity will be given to members at a full meeting of the Society.

Mr. Holroyd said: I may add, in answer to Mr. Scowcroft, that in our experiments the water could not escape from the cylinder, and whatever moisture there was in the peat, leaves, or shavings, had to remain there during compression. The only way out when the pressure became greater than the binding force of the cylinder, was by breaking it. But on the earth's surface, whatever the pressure from above, there has always been room for water to escape laterally.

Mr. Scowcroft: I quite agree with you, but what made me ask the question was this: Mr. Barnes seemed to lay special stress on the words "water must be absent." I thought he was doing it just to introduce the subject.

Mr. Barnes: It referred to our experiments. We were describing our own work.

Mr. Scowcroft: I thought you were speaking in a general sense.

Mr. Barnes: That is what we wished to infer precisely.

Mr. Holroyd: Only the water had a way to get out, which it had not in our case.

ON THE OCCURRENCE OF A SEA-BEACH AT CASTLETON, DERBYSHIRE, OF CARBONIFEROUS LIMESTONE AGE.

By Messrs. J. Barnes, F.G.S., and W. F. Holroyd, F.G.S.

The making of the new railway to Hope, on the Dore and Chinley line has opened up the district of Castleton, and a much larger number of persons visit this place than formerly.

These visitors require accommodation, and many new houses and restaurants have been erected. To supply material for the building of these, and for new walls, new quarries have been opened into the limestone rock, and other quarries have been extended.

Geologists, inquisitive beings, impelled by curiosity, naturally visit these places in search of fossils, new and rare. We visited one of these little quarries last year (1895,) a quarry which lies on the slopes of the hill known as Cow Low, in a field near the roadside leading to the Winnats from Castleton, and between Peak Castle and the Speedwell Mine. The quarry exposes some of the upper, if not the uppermost beds of the mountain limestone of the Carboniferous system of North Derbyshire. There are also several small quarries on each side, and similar beds are found extending in a line for about a mile. These, although they present similar features, have not these peculiar features so pronounced as the one we are describing. We found the limestone in this quarry had a very peculiar appearance, which, at that time, we had not noticed elsewhere. It was a conglomerate, the harder rounded portions of which, on close examination, were found to be fragments of rolled and water-worn shells. These fragments are exceedingly numerous, and well rounded, and they make up the bulk of the rock.

On some of the fragments the external ornamentation, striæ, basis of spines, &c., are plainly visible, while on the internal portions, the muscle scars, hinge lines, &c., are equally prominent, on many others, all these means of identification are entirely obliterated. That they are actually derived from water-worn and rolled shells, then, is very obvious, on examination of them in the quarry, and also that they are actually portions of shells is also evident from the fact, that the fragments have convex and concave sides, and show the internal structure of ordinary fossil molluscs. In some parts of the quarry, the rock owing to its curious lithological composition, is very friable and easily falls into decay, but where the rolled fragments are not so numerous, the rock is hard, compact and coarsely crystalline.

The physico-geological features of the quarry and the position of the beds are quite ordinary, as may be seen on referring to the diagram below. The beds dip to the north-west at 15°.

The uppermost bed, under the subsoil is of a loose incoherent material, entirely composed of rolled fragments of shells, most of them oblong, and with hollow and flat portions of valves, both dorsal and ventral, and also right and left. This bed is from four to five feet in thickness. The underlying beds are more compact, but still consist of shell débris of well crystallized and well cemented rock. The lowest beds exposed in the quarry are massive, and consist of large blocks of crystalline limestone, with encrinital stems and fragments of the above-named rolled shells. The total thickness of the beds exposed is thirty feet.

The weathered appearance of the limestone as seen on the exposed joints, and on stones on the walls, is peculiar, inasmuch as the limy cementing material being finer, is more easily acted upon by the usual disintegrating agents,

while the pebbles of rolled shells stand out clearly, like the pebbles in a conglomerate, but also lying parallel, or nearly so, to themselves and to the bedding planes. In a quarry at the foot of Tray Cliff Hill, and in another quarry on the road to Pin Dale, fragments are to be found in great abundance, and from three to four inches in length. Here, too, the encrinital stems are to be found in all stages of attrition, from the least worn to the mere stem, devoid of all markings.

These are prominent upon the flaggy stones which form the higher beds, superimposed upon the beds containing the best rolled fragments. These flaggy beds are themselves overlaid by thin shaly limestones, which are the base of the Yoredale rocks. In this quarry also is to be found a more numerous suite of fossil remains, including flat pavement teeth of Psammodus, separated valves of Spirifera, Rhynconella, Athyris, &c., in addition to the valves of Producti. The inferences we have drawn from an attentive examination of the fragments, the beds, the fossils, and the strata generally, are as follows. Since these beds are the uppermost of the mountain limestone of Castleton district, it is evident that during the time of the Lower Carboniferous sea here, that there must have been a partial uplifting of the sea bottom after the deposition of the lower beds, and then a subsidence again, because it is necessary to have a sufficient uprising to produce a beach upon which the incoming tides could have brought the marine organisms from the neighbouring sea bottom, which organisms are now found as the rolled and worn fragments represented in the bulk of the material constituting the rock exposed at this spot. That there must have been a subsidence is proved by the thickness of the beds above, which could only have been produced by the land or beach becoming slowly depressed, and allowing of further accumulations of

the débris of the marine shells. There is evidence also from the fact that the Yoredale shales and grits immediately overlie these beds, that there was along with the subsidence of the beach a distinct change in the sediment of the succeeding deposits. From calcareous to muddy deposits, and from an abundant marine fauna to a comparatively meagre one, this seems to be the order of the change.

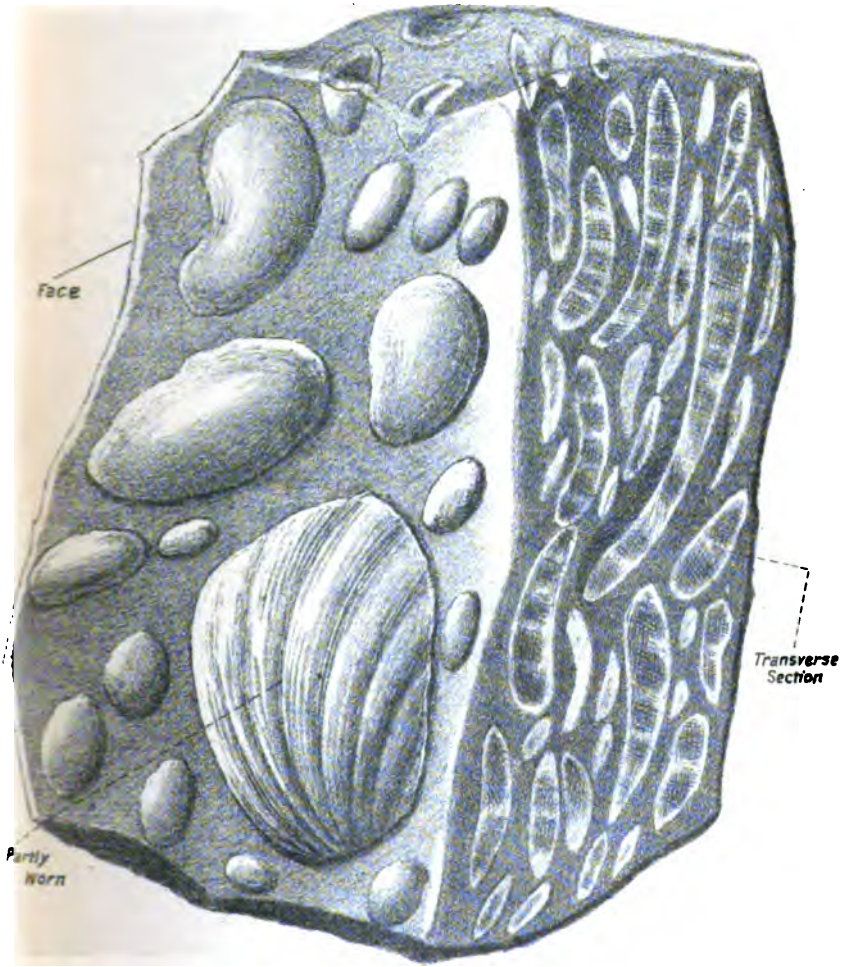
Professor Hull, in his "Physical History of the British Isles," folio 84, says :—

"On the commencement of the Lower Carboniferous stage the sea everywhere occupied the submerged tracts, bathing the sides of the uplands and mountainous parts, and bringing with it multitudes of marine animals, so that the oldest Carboniferous strata in Ireland, England, Wales, and Scotland contain numerous marine forms. During the subsequent epoch of the Carboniferous limestone the depression proceeded, and the sea ascended on the flanks of the uplands until only the very highest elevations were left uncovered.

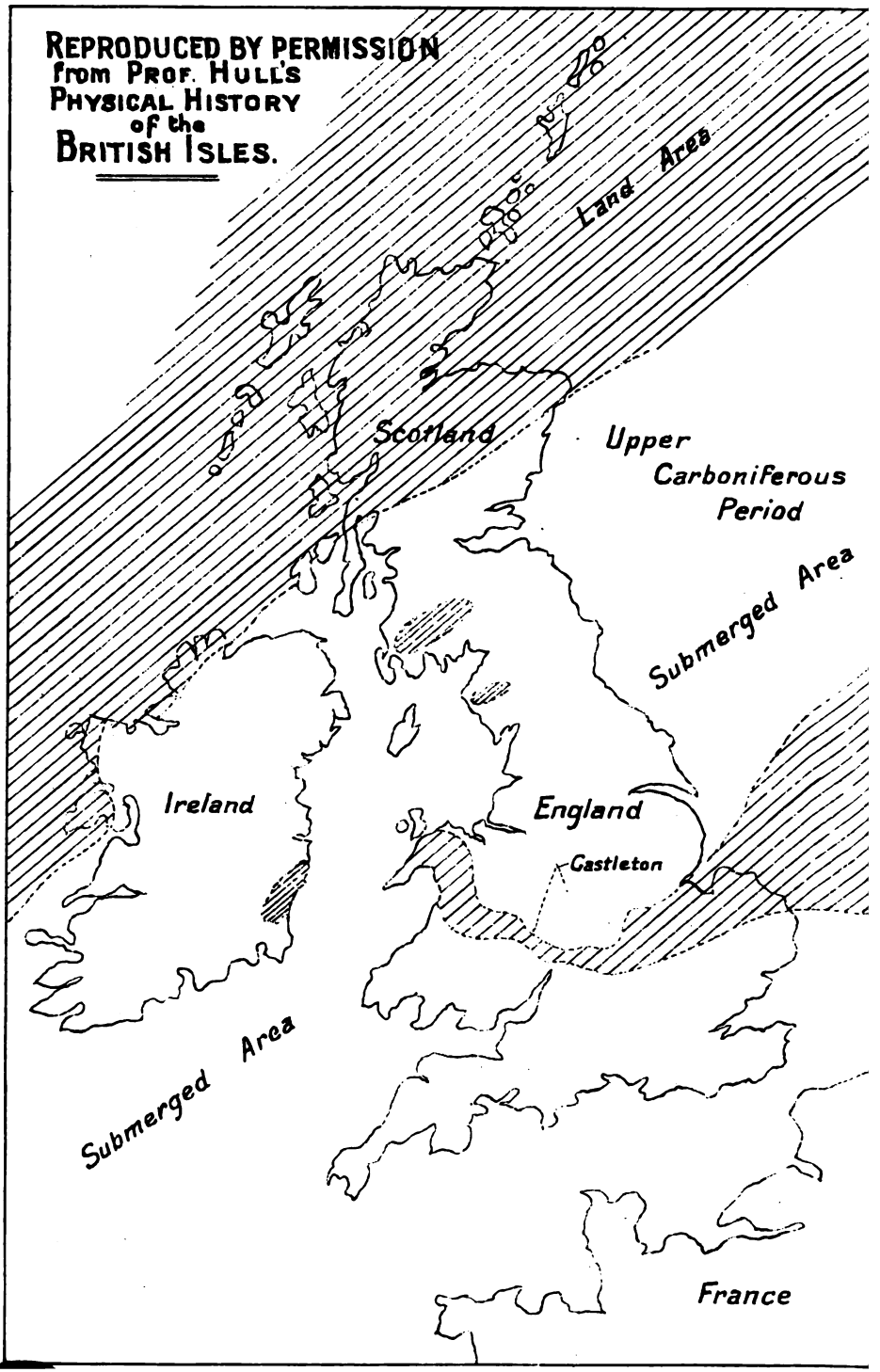
Deep-sea conditions prevailed over the north and south of England and the centre of Ireland, and here the calcareous beds were formed in greatest thickness and purity through organic agency. A tract of country extending across England, from Shropshire, through Worcester and South Staffordshire, remained as a ridge or land barrier, separating the basin of the north of England from that of the south, as the Lower Carboniferous rocks are absent, or only present as *thin marginal representatives* along this line of country."

It is one of these marginal representatives which we claim to have discovered at Castleton, thus bringing the hypothetical land area crossing the Midlands further north than has hitherto been known.

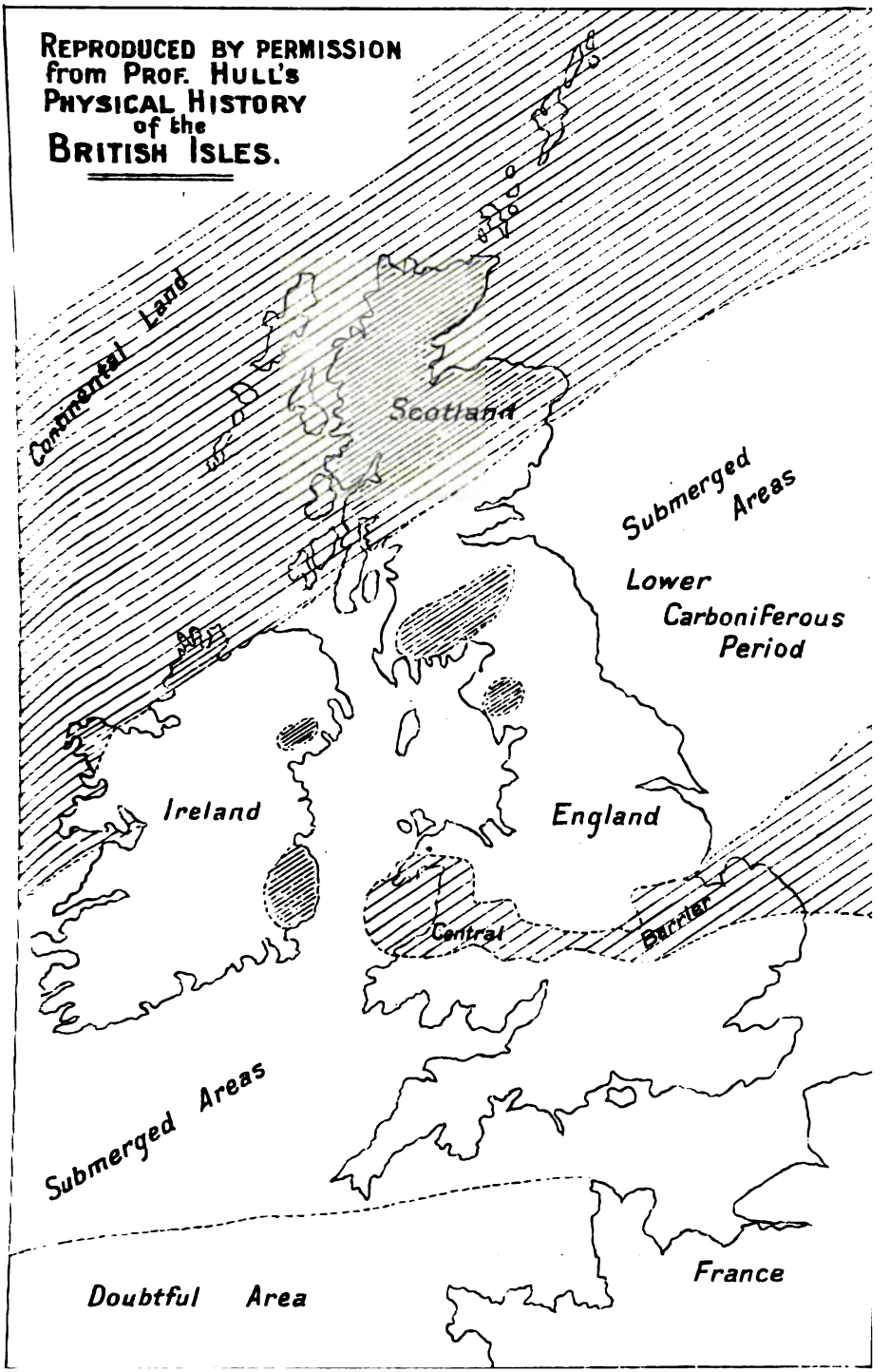
The question arises—Upon which side of this beach did the sea at this period lie: was it to the north or to the south

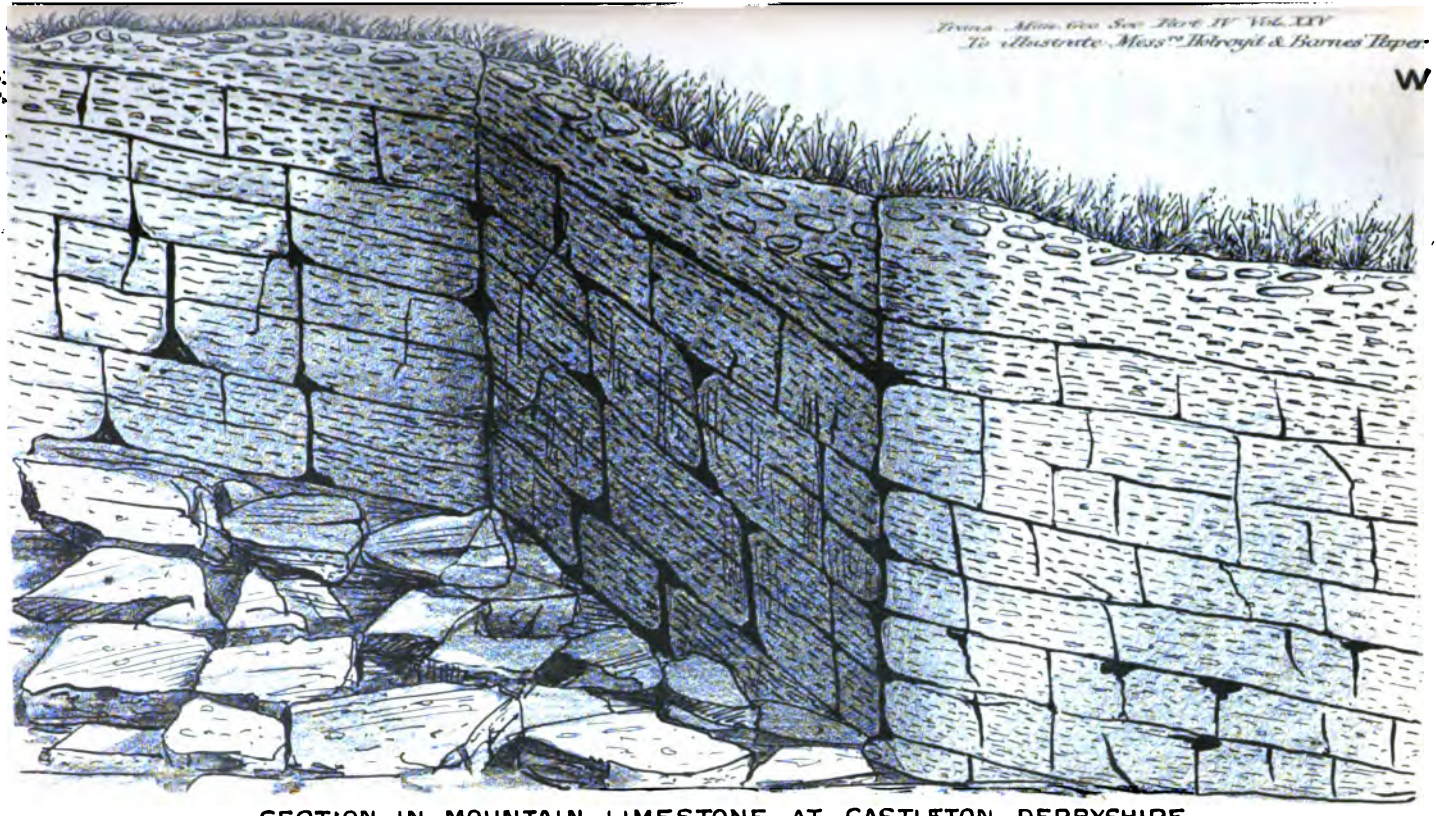


Block of shell conglomerate showing rolled fragments of shells, one of which shows faintly the external ornamentation, the others with it completely worn away.


REPRODUCED BY PERMISSION
from PROF. HULL'S
PHYSICAL HISTORY
of the
BRITISH ISLES.
Land Area
Scotland
Upper
Carboniferous
Period
Submerged Area
Ireland
England
Castleton
Submerged Area
France

Trans. Man Geo Soc. Part IV. Vol. XXV
To illustrate Messrs Holroyd & Barnes' Paper





SECTION IN MOUNTAIN LIMESTONE AT CASTLETON, DERBYSHIRE.

Upper beds of friable shell débris,
Lower beds more compact limestone with rolled worn shells.

of it? From very good evidence that we possess, it is probable that the sea lay to the south, for to the south of this place we find numerous fossiliferous beds, viz., those in Cave Dale, of previously existing molluscan life, and there is also a very extensive coral reef, which may be called a fringing reef, some four or five hundred yards distant, and further south, and also running nearly parallel with the beach east and west. It is probable that these worn rolled shells were derived from the beds, where these molluscs lived, that is, in the infra-littoral or rather deeper water, because of the ebbing tides to the south and the return flow tides setting to the north, which brought them and deposited them where they are now found, and which produced the constant trituration, the results of which are commonly known to people who have visited our own sea coasts, and which are seen on the fossil sea-beach we are describing.

This hypothesis shows that to the north of this beach there must have been some land area. How much north of Castleton we should not like to say, whether it was simply a tongue or narrow strip of land that ran east and west, or whether the sea was in existence farther north, say as far as Clitheroe, where the limestone again crops out, we are not in a position to say, nor should we like to say how far east the shore extended, but that it did not extend continuously very far west of Castleton is proved by the fact that it probably sweeps around Tray Cliff Hill, under Mam Tor, beyond Windy Knoll, to the south at Sparrow Pits, where we have found it, and we have traced it also further south to Glutton Dale, near Longnor. We are able to make this statement because, strange and interesting as it is, we find at Glutton Dale quarry, the same kind of rolled fragments and shells, and to the south of this, we again find the highly fossiliferous beds on Park Hill, near Longnor,

bearing a similar relationship to the beach at Glutton Dale that the fossiliferous beds of Cave Dale do to the beach at Castleton.

From this land area, north and west, sediment was carried down into the sea, and quartz pebbles were carried into it, one of which is exhibited here, and are now found embedded in the limestone. This point shows that the land at Glutton Dale and district, shoaled at that part to the westward.

With respect to the beds at Sparrow Pits, as shown in Bolt Edge quarry, the pebbles there are very much smaller than those at Castleton.

The question arises why are the shells so much more comminuted? Is it probable that there was a much more violent tide, with a steeper shore, or had the numerous cestraciont fishes, the teeth remains of which at Bolt Edge are very common, any part in reducing the shells to smaller fragments than those found at Castleton?

It is interesting to note too, that at Castleton there have been found on two different occasions, by ourselves, teeth of Psammodus, but these not in anything like the same abundance in which they used to be found at Bolt Edge quarry.

This finding of the same series of fossils, rolled fragments, &c., at each of the three named localities, we take to be highly corroborative of the hypothesis we have promulgated in this paper.

One interesting point in connection with this sea-beach is, that wherever it is noticed, we can predict that we shall find the most fossiliferous beds of the mountain limestone not far away, so that on the other hand, if one notices evidences of the fossiliferous beds, we may be sure that we are not far distant from the beach. Another interesting point is, that it is very probable that the land area at Castleton, during the upheaval of the later Carboniferous

Limestone period, produced a local land surface of Carboniferous sediment itself, because we have further west, in the front of Mam Tor that is to the south of it, a very striking instance of a distinct unconformity existing, locally, between the limestone and the Yoredale shales, that is, we have a very irregular and worn surface of limestone rock with Yoredale shales laid upon this at a different angle. This is very different to the common arrangement usually found, where we have a gradual passage downward from a shaly limestone, to a proper thin limestone, and thick, massive crystalline limestone itself, as is shown in a quarry on the road to Pin Dale, a little to the east of Castleton. The present marginal contour line of the mountain limestone, nearly corresponds with the ancient shore-line, so far as we have investigated it, on the north and the south-western side.

This would indicate, that from the earliest times, the, earth's crust in this neighbourhood was of a weak character, or of such a character, at all events, as lent itself readily to upheaval, depression, and faulting.

It is also an interesting fact, to note that in the beds at Sparrow Pits, near Chapel-en-le-Frith, there is, along with the shell dèbris of which the limestone is mainly composed, a fairly large amount of quartz of a well rounded character.

The limestone here is also fairly rich in phosphates.

The limestone at Castleton does not show anything like the same amount of silica as that of Sparrow Pits, but about the same amount of phosphates.

From what has been said, it will appear that the generally prevalent idea that at Castleton deep sea conditions prevailed during the deposition of the Mountain Limestone can no longer be upheld. Deep sea conditions may have at earlier periods prevailed, but the beds formed during the later limestone era, and to which alone we have access at Castleton, were laid down in a shallow sea.

The PRESIDENT: I think we are greatly indebted to the authors of the paper for the extremely interesting facts which they have presented to us. Many of those present may know the district of Castleton, but may not have been able to draw from it so much material for thought and study as Messrs. Barnes and Holroyd have done. Our thanks are due to both those gentlemen in a very large measure, and I am only sorry that a larger number of the members have not been present to-night to listen to their most interesting and practical paper. The facts have been very clearly stated, the inferences drawn from those facts are proper subjects for debate, and after a vote of thanks to Messrs. Barnes and Holroyd has been moved and seconded, I shall be pleased to hear what any gentleman may have to say upon them.

Mr. SCOWCROFT: Mr. President and gentlemen, I have great pleasure in moving that the best thanks of this Society be given to Messrs. Barnes and Holroyd for their valuable papers.

The vote of thanks to Messrs. Barnes and Holroyd was seconded by Mr. ATHERTON, who continued: In the section before us of the strata at Castleton, do you find the facings break off at right angles to the true dip?

Mr. HOLROYD: Yes, they break off quite clean and sharp.

Mr. ATHERTON: Would you consider the upper beds unconformable.

Mr. HOLROYD: They are quite conformable, so far as we have noticed them, but we cannot say that they break up into jointing. Beginning at the top one finds the jointings more and more distinct as one gets downwards.

Mr. BARNES: It appears to be a case of the upper beds weathering into the soil, and the more compact side falling into loose materials.

Mr. Atherton: On a previous occasion Messrs. Holroyd and Barnes took us over Pule Hill, and I think a similar pleasant afternoon could be spent by us if they would be good enough to pilot us over the ground they have described in so interesting a manner at Castleton.

The President: Castleton is now very easily got at by the Midland Railway, and I have no doubt Messrs. Holroyd and Barnes would willingly lead an excursion on a suitable occasion. Of course it would be impossible in the course of one afternoon to go over the whole of the ground covered by their observations, because it extends from Castleton to Longnor.

The vote of thanks was then put to the meeting and carried unanimously.

The President: The discussion, gentlemen, is now open, and I shall be glad to hear if any member has any observations to make or desires to ask any question which may lead to discussion. I recall to mind a paper that was given to the Society many years ago by the late Mr. John Plant, in which he described what he believed to be a sea-beach at a place called Grin Hill, above Buxton. Quarrying operations had gone on there for years, and he described how, on removing the surface soil, the top bed of limestone rock was found to be waterworn. This "waterworn" rock is, as most of you will have noticed, much used in the construction of rockeries and other rustic work in gardens. Of course the thing described was not a sea-beach at all. It was produced by a percolation of surface water on to the top bed of limestone, wearing it into hollows and furrows, some deeper and some shallower, and giving the rock its peculiar waterworn appearance. Similar stone is got now as new quarries are opened out. I do not think Mr. Plant would, some few years after, have stuck to the theory of its being an ancient beach. Such a view was wrong altogether.

But the beach we have heard of to-night from Messrs. Barnes and Holroyd is of a different character. They have given us very distinctly the facts on which they claim the beds at Castleton to have been a sea-beach, and I do not myself know of any similar example in Derbyshire. It seems—as they have inferred—as if this bed of the sea had been uplifted during the formation of these limestone beds, and had been brought into communication with the atmosphere and with shore conditions, where the tides could operate upon it and roll these shells; and where also, possibly, some weathering on the sea-beach might take place on these fossils. But in the upper beds which have been described I take it some weathering may be going on still, and they are gradually getting broken up. Well, you see that on the tops of all rocks. For instance, near Conway, on some of the hills, the rocks are being broken up into shaly fragments. It feels to the tread as if you were walking over an old slate quarry. That breaking up is the effect of frost, rain, and other conditions. But Messrs. Barnes and Holroyd have disclosed a remarkable example where, in the course of laying down these limestone deposits, you have a long interval of time during which these corals lived, the water being comparatively shallow and afterwards regaining somewhat of its original depth. Corals, we know, do not require, and indeed will not live, at great depths in the ocean; therefore, the finding of these corals at Castleton is pretty clear proof that the water in that ancient sea at that spot was not very deep, and similar remains, it would appear from the paper, are to be traced from Castleton as far as Longnor. Beyond that, I suppose, they have not yet traced it.

Mr. Holroyd: We have traced it a quarter of a mile eastward of Castleton, but not further. We shall continue our investigations in that direction.

The PRESIDENT: The evening, I am sure, has been very instructive to all of us. With regard to the maps from Professor Hull's book they must, of course, be taken as purely hypothetical. Hull's "Central Barrier" has, I know, been disputed by some geologists, though probably its main facts are tolerably correct. It is diffcult to draw maps of that character, showing land and sea at early geological epochs: still, the attempt has been made, and the sketches before us give a good idea of what Messrs. Holroyd and Barnes, in their paper, wished to convey. Professor Hull tried to locate the land area from which the millstone grit was derived. It must have come from the degradation of some continental area, and this he has drawn a little to the north-west.

Mr. A. SINGTON, replying to the President, said: I have never noticed these special features in the Castleton district. The new quarries have been opened since I was last there. I think the facts these gentlemen have given us are absolutely convincing, and fully establish their theory of a sea-beach. When at Castleton I have often sought for some evidence of actual contact between the limestone and the Yoredale shales, but I have never succeeded in finding any. There is, however, a specimen on the table exhibiting it. May I ask the authors of the paper if they will kindly state the exact spot where it was procured?

Mr. HOLROYD: At the foot of Tray Cliff, and in the direction of Windy Knoll.

Mr. SINGTON: I have been over every foot of that ground, but must have overlooked it.

Mr. HOLROYD: The best place is above the Odin fissure—more on the top. There you can see the shales resting unconformably on the limestone. And there are other places in the district.

The PRESIDENT: And these are unconformable?

Mr. BARNES: Distinctly unconformable. There must have been a considerable lapse of time between the uplifting of the limestone and the deposition of the overlying strata.

Mr. HOLROYD: One observation by the President brings out an interesting point. He said that Manchester geologists often visited Castleton, and as a rule found lots of fossils, which were plentiful there. Why do we get such abundance of fossils at Castleton, at Park Hill, and some other places? It is simply because there the waters were infra-littoral, and there the molluscs lived in the greatest abundance. It is well known that they do not live in the deep seas in any great numbers.

The PRESIDENT: I must take exception to that, because some molluscs were dredged by the Challenger Expedition from very deep seas.

Mr. HOLROYD: Found living?

The PRESIDENT: Found living in some of the greatest ocean depths, but not in any quantity.

Mr. HOLROYD: Here at Castleton we have them in the greatest abundance. You cannot break a piece of limestone without finding them in quantity.

The PRESIDENT: That may be accounted for by what we find going on at the present day. In the investigations of late scientific expeditions it has been shown, as the result of dredging, that in some places the sea floor is quite destitute of living organisms, whilst in other places life is found in great abundance. There would seem to be something that attracts certain creatures to particular localities. No doubt it is food. The nature of the ground has some attraction, but molluscs and all kinds of invertebrata, it may be assumed, go where they can get the best food.

Mr. HOLROYD: Not many weeks since I attended a lecture, when the lecturer spoke of the sea which must have

covered the Castleton area in the Carboniferous limestone age as a deep-sea area, and the deposits of limestone there as deep-sea deposits. Now, as a matter of fact, it is almost quite the opposite. The waters must have been shallow waters in which those deposits took place, so far as we know anything about it. The President was right in saying that the molluscs go where they can get the best food, but you must remember that in the deeper parts of the ocean the water is stationary below the depth of a few hundred feet. That is not a place either where these creatures are able to live, from the pressure of the superincumbent waters or the absence of food supplies; but they live in the waters which are constantly in motion, usually on the slopes at a depth of from 10 feet to 200 feet. That is the position where you will find these creatures in the greatest abundance, in what is known as the infra-littoral zone.

The PRESIDENT: You spoke of having found in some places shells very much comminuted, and mingled with fish remains. It is a question whether these shells had not passed through the stomachs of the fishes—sharks or other—which lived in the same seas. That may account for the grinding of the shells.

Mr. BARNES: Exactly so, and the fish remains found were those of species that would prey on molluscs.

Mr. HOLROYD: I am sorry we have not brought to-night a box containing fish teeth found at Castleton. We have a large number of teeth from the Sparrow Pits district—some of them mounted with small portions of the comminuted shells. It was the suggestion of my colleague, Mr. Barnes, that this was one explanation, it is quite probable that some at least of the shell remains we find must have passed through the stomachs of fishes, as the President has

stated. Very likely many of the shells, after being crushed by the flat teeth of the fishes, were passed out from the mouth again when the soft bodies of the molluscs had been extracted.

The PRESIDENT: Has any gentleman any further question to ask?

Mr. LINDSEY: You spoke of quartz having been found in the limestone. Was it disjointed fragments?

Mr. HOLROYD: Not at all, but an entire well-rounded pebble. It was a solitary pebble, but we have every reason to believe that many more might be found if carefully sought for.

Mr. LINDSEY: What I wish to ask is this: You have examined many microscopical sections of granite, and the quartz in that granite, in the majority of cases, looks as if it had been the last to solidify, and had filled up the whole of the interstices. In that case would you not naturally infer that that had been deposited in the same way—that it had crystallised out?

Mr. HOLROYD: We do not mean to say that the quartz had crystallised out from the sediment of the carboniferous sea. What we say is that this quartz pebble was entirely derived from some pre-existing land surface.

The PRESIDENT: That undoubtedly was the case. The pebble must have been washed in at the time of the deposition of the limestone.

The discussion being closed, the members made an inspection of various microscopic sections of carboniferous plants, and a large display of polished sections of fossil corals, and also a number of rolled waterworn shell fragments, and shell conglomerates with pebbles, in illustration of the paper.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART V. VOL. XXV. SESSION 1896-97.

WIGAN MEETING.

The ORDINARY MEETING of the Members was held on Friday, January 8th, 1897, in the Mining School, Wigan.

The President, Mr. MARK STIRRUP, F.G.S., in the Chair.

NEW MEMBERS.

The following gentlemen were balloted for and duly elected Ordinary Members of the Society:—

Mr. GODFREY BAKER, Colliery Manager, Pendlebury.

Hon. WILLIAM BROOKS, J.P., Crawshaw Hall, Rawtenstall.

Mr. F. S. McCALLAM, C.E., Chapel Walks, Manchester.

Mr. H. R. MAKEPEACE, H.M.I.M., Newcastle-under-Lyme.

Mr. C. H. PEARCE, Hulton Collieries, near Bolton.

Mr. G. H. WINSTANLEY, Mining Engineer, Manchester.

The PRESIDENT, in opening the proceedings, said that in his Inaugural Address, at Manchester, no reference had been made to the Wigan meetings of the Society. Wigan had, however, from the first inception of the Society, as would be seen from the earliest list of members, recognised the value of such an institution. Hence the first meeting held

in Wigan was shortly after the foundation of the Society in Manchester. This first Wigan meeting was held on the 29th April, 1840, in the Town Hall. Mr. Ralph Thicknesse, jun., occupied the chair, and Mr. Peace read a paper on the dislocation of the coalfields in the neighbourhood of Wigan, on which a discussion ensued. Mr. Bowman read a paper on the fossil plants found in the Coal Measures. Mr. Eaton Hodgkinson, F.R.S., read a paper on "Observations on the temperature of deep mines in Lancashire and Cheshire;" and Mr. Adcock one on "An invention for raising water from mines and other deep places." Several distinguished gentlemen were present, among whom were Mr. Nasmyth, James Heywood, F.R.S., Dr. Black, and William Fairbairn—names afterwards notable in the ranks of science and industry. The Society thus started its Wigan meetings under good auspices, the papers given being of a practical character. The Society also undertook at this meeting to prepare sections of the strata from near Bolton to the Irish Sea, and some sections of local interest were presented to the Society on this occasion.

THE EFFECTS OF PRESSURE ON VEGETABLE MATTER.

Mr. Scowcroft brought before the meeting a paper previously read at the Manchester meeting by Messrs. Holroyd and Barnes, and showed specimens on the effects of great pressure on decaying vegetable matter.

(See Paper, Part IV. of the Society's Transactions.)

The President said the inference to be drawn from the paper was that the method the authors had adopted was to show that pressure has had much to do in the making of coal.

Mr. Scowcroft referred to the statement that the small particles in the compressed leaves were small coal crystals; it appeared to be a question of degree.

The President said he did not see how anyone could say that carbonaceous matter was formed by the pressure. Coal was formed by chemical processes and mineralisation acting through vast periods of time upon vegetable matter, and he did not see how they could compare the pressure exerted in an iron tube on vegetable matter with the vegetable matter that had been subjected to pressure and mineralisation during long centuries. He did not think there was the slightest proof that any carbonaceous matter, such as bits of coal, had been formed by the experiments. All that had been done was to compress leaves into a hard solid substance. With regard to peat, there had been many experiments with a view of pressing out the water, in order to use the peat in manufacture, but the experimenters had generally found that more money had to be spent in coal to provide the power to drive off the water, than the peat, when compressed, was worth. He did not think there was much probability of anyone adopting these experiments in the hope to make coal.

Mr. Kelsall considered the paper instructive. They must bear in mind that the authors had made the experiments in a very short time, whereas the formation of coal had occupied centuries. The experiments showed, he thought, what could be done by pressure, and what part it played in the formation of coal. With reference to that formation the examination of a peat bog is very instructive, affording examples of vegetable matter in every stage of decomposition, from that in which the organised structure is still clearly visible, to the black carbonaceous mass which only requires consolidation by pressure in order to resemble a true coal, and we know when this vegetable matter has been entombed

for thousands of years, undergoing changes due to the great pressure upon it, and the chemical actions going on within it, that we then have the coal in its true form. Thus the authors have demonstrated what can be done by pressure in a short time, and I must say reflects great credit upon them.

The PRESIDENT said the shining particles on the exterior were said to be carbonaceous matter, and the inference was drawn that they had been formed during the course of the experiment. He considered this part of the paper illusory. He did not believe that even under the pressure exerted any carbonaceous matter could be formed during the time allowed.

Mr. GERRARD said to jump from peat, even by means of lignite, to coal was a very big jump. The paper was interesting, and if it was intended to convince anyone with regard to the vegetable origin of coal, it would succeed. If it was intended to show, however, that all coal had been peat, it would not be accepted, as there were many divisions of coal formations that had no connection with peat. He should like to know what was the amount of compression, *i.e.*, what proportion did the volume of the compressed peat bear to the original bulk.

Mr. SCOWCROFT said the cylinder was 3in. deep and 3in. in diameter, and the decrease in volume brought the matter to about one-fifth of its original bulk.

Mr. WINSTANLEY asked the President whether he remembered some experiments conducted by M. Dupré in the same direction as those of Messrs. Holroyd and Barnes.

The PRESIDENT said he did not recollect any experiments such as those put before them that day.

Mr. HALL remarked that apparently the authors had simply compressed a substance to something less than its original size. He thought the edges would be the very

places where coal would not be found, as the pressure was less there than on the material vertically below the press. The particles which the authors thought to be coal were, in his opinion, simply due to the compressed peat at those points rubbing against the iron tube, and taking some of its colour.

The PRESIDENT said numerous theories had been propounded to account for the formation of coal and referred to the theory of a German geologist, that coal was all made from marine vegetation because it contained iodine and bromine, which would not be found if it were simply composed of land plants.

THE IMPROVED FLEUSS BREATHING APPARATUS.

By Mr. GEORGE H. WINSTANLEY, F.G.S.

Illustrated by means of lime-light views, together with an exhibition of the apparatus with experiments, &c.

INTRODUCTION.

Every review of the history of coal mining brings before us the numerous and great advances which have been made in connection with colliery operations during the past hundred years. Improvements calculated to reduce the expense of working, improvements intended to secure the safety of those engaged, have been carefully planned out, and to a very great extent successfully adopted; but there is one direction at least in which little or no advance seems to have been made, viz.: facilities for rescuing those whose lives are endangered when, in spite of all precautions, an

accident has happened. This, of course, refers more especially to explosions of gas or coal dust, which, although much less frequent than formerly, still, it is to be regretted, have from time to time to be recorded.

A colliery may be provided with high-class ventilating machinery; the workings may be ventilated most systematically and scientifically; safety lamps of the most improved type may be adopted, carefully selected explosives used in connection with the safest system of firing may be employed; and still in spite of all these precautions we know only too well that an explosion is by no means impossible. The improvements, however, seem to go no further, and, in the event of such a disaster, it would seem as if the facilities for rescue work were no greater than in the days of George Stephenson.

The Invention of the Fleuss.

The Fleuss apparatus is by no means a new invention; it must be nearly twenty years ago since Mr. Henry A. Fleuss brought out the appliance. In 1880 it was in practical use for several weeks at the re-opening of the Maudlin seam at the Seaham Colliery after the explosion there. A year or so later it was the means of rescuing alive 10 men at the Killingworth Colliery.

In spite of this the Fleuss apparatus cannot be said to be a recognised colliery appliance. So few sets of the apparatus have been supplied that the writer was recently telegraphed to from London to send the present appliance to the flooded colliery at Aberdare, where it was thought that the appliance might possibly be used, apparently this set of apparatus being the nearest available one.

In explanation of this, it must be admitted that the earliest form of the appliance was not exactly suitable for mining work, especially in thin seams, it was somewhat heavy; and

what was a still greater drawback, it was very bulky. The original apparatus, however, has been much improved upon in this respect, and it is now made lighter, far less in bulk, less costly, and it is not at all complicated. As regards the bulk and weight, the writer proposes to describe, and exhibit in a practical form, a still further improvement which he has suggested and adopted, which will make the Fleuss apparatus a more practicable appliance for use in coal mines.

Explosions in Coal Mines and Loss of Life.

It is now generally admitted that the loss of life attending an explosion of gas or coal dust in a mine is not so much due to the actual and direct effect of the explosion as to the effect of the explosion upon the atmosphere, which has a large proportion of its oxygen consumed, and at the same time becomes charged with poisonous and irrespirable gases —principally the two oxides of carbon, carbon mon-oxide, and carbon-dioxide. Both of these gases are harmful to health and life, and may cause death. The former particularly is an intensely poisonous gas; it is formed by the incomplete combustion of almost any substance containing carbon, or by the combustion of such a substance in a limited supply of air. It is nearly always given off with the other gases resulting from a gob-fire or spontaneous combustion underground, and many explosives produce this gas on detonation. In his most valuable paper, read before the North of England Institute, Dr. Haldane states that an atmosphere containing carbon mon-oxide to the extent of 0·10 per cent. would cause helplessness after breathing about an hour; with more than 0·20 per cent. life would be endangered. Dr. Haldane further leads us to the conclusion that in many cases the men who ultimately lose their lives after an explosion are for some time prior to their actual death simply rendered insensible by the action of the poisonous

gases in the after-damp; and that if it were possible for the rescue party to enter the mine immediately after the explosion many lives might possibly be saved.

The same circumstances, however, which render the men in the mine insensible, also make it impossible, under ordinary conditions, for the rescue party to reach and rescue them. They are compelled to wait until the ventilation is improved, and in many cases they can do very little even in the way of helping to restore the ventilation. Doors may be blown down, air-crossings may be injured, and the ventilation cannot be made good until these have been replaced or repaired, often an impossible task owing to the irrespirable atmosphere.

The Fleuss apparatus was invented in view of these difficulties, and its object is to enable a person to enter, and for three or four hours remain in an atmosphere charged with the most poisonous gases. This is accomplished by rendering the person using it entirely independent of the surrounding atmosphere. The Fleuss apparatus, in fact, does with regard to irrespirable gases exactly what the diving dress does with regard to the water with which the diver is surrounded. There is this very important difference, however, which makes the Fleuss particularly suitable as a mining appliance. The ordinary diving dress and apparatus is connected, by means of long lengths of flexible hose, with an air-compressing pump, which keeps the diver constantly supplied with fresh air. This hose, and also the signal line, can, of course, be manipulated without much difficulty in ordinary diving operations, but they prove serious obstacles in connection with the work of exploration underground; every corner which had to be turned would increase the difficulties in the way of the diver's further progress, and would also be a source of danger to the diver himself, there

being always the possibility of the hose being damaged. In the same way his signal line would be useless under such circumstances. In the Fleuss apparatus these difficulties are overcome in a very ingenious manner: the person using it carries his own atmosphere about with him in a quantity sufficient to last for three or four hours, and provided with an electric safety-lamp, he would be enabled to penetrate any portion of the workings which were not actually rendered inaccessible by falls, &c.

How the Breathing is conducted.

To follow the action of the Fleuss apparatus it will be necessary for a moment to consider briefly the operations of ordinary respiration. The necessary element in the atmosphere to support life is oxygen; this gas is mixed with nitrogen, the latter merely acting as dilutant, and in no way entering into the actual process of respiration. The air which is drawn into the lungs is enabled to act upon the blood, and a process of combustion goes on, the oxygen combines with some of the carbon in the blood to form carbon-dioxide, and this, together with the nitrogen, is exhaled into the atmosphere. It will thus be seen that if a person were placed in a sealed chamber, he would by his breathing gradually use up all the oxygen, and at the same time charge the atmosphere with a gradually increasing percentage of carbon-dioxide. This would go on until the person became insensible and finally expired.

In order to permit healthy respiration therefore, two things are essential. First, there must be some means of maintaining a supply of oxygen, and secondly, some means of removing the excess of carbon-dioxide. How these are accomplished in nature it is not our present purpose to enquire; in the Fleuss apparatus, the necessary conditions are brought about in the manner now to be described.

Description of the Apparatus.

The original apparatus consisted of a mask to cover the face, a copper cylinder containing a supply of oxygen gas under pressure, a rubber bag worn in front and called the breathing bag, and the carbonic acid gas filter, together, of course, with the necessary tubes connecting the different parts and the straps for the purpose of carrying.

Fig 1.

THE ORIGINAL "FLEUSS."

A. The Mask.
B. The Carbonic Acid Filter.
D. The Oxygen Cylinder.
G. The Breathing Bag.

The Carbon-Dioxide Filter.

The arrangement referred to above as the carbonic acid filter, in the original apparatus took the form of a rectangular box strapped to the back like a soldier's knapsack. Internally the box was divided into vertical compartments, each filled with tow impregnated with caustic soda. Up and down these compartments the exhaled breath was made to pass, and in this way was freed from its carbon-dioxide. Caustic soda has the property of actively combining with this gas, forming carbonate of soda.

From the view shown it will be seen that this arrangement was most unwieldy, in fact, quite useless in any but a mine where the roads were uniformly high, and where no small places had to be passed through. In the present form of the appliance, however, this cumbersome arrangement has been dispensed with entirely, and the caustic soda, in the form of sticks, is placed in the breathing bag.

The Mask.

This is made in two forms, one simply covers the nose and mouth, and would be generally used in mining work; the other also covers the eyes, and would be used in smoke or fumes injurious to the eyes. In both cases the mask fits closely to the face, and is provided with two corrugated rubber tubes, one being the tube for inspiration and the other for the exhaled breath; each tube is provided with an exceedingly simple valve which responds to the very feeblest efforts of breathing.

The Breathing Bag.

The mask is connected with the breathing bag by means of the corrugated tubes referred to above, the bag is of good rubber, and is worn in front, occupying very little space. Internally the bag is divided into two compartments, into each of which a quantity of stick caustic soda is placed (2 lbs.) when the apparatus is to be used.

The Oxygen Vessel.

It is in connection with this portion of the appliance that the writer has attempted to make some further improvements, by reducing the weight and bulk of the apparatus as well as increasing its utility as a life-saving appliance. The oxygen cylinder supplied with the set of apparatus by Messrs. Siebe, Gorman, and Company, the eminent firm of submarine engineers, who are the sole makers of the apparatus, is made of copper. The writer believes that copper was chosen in the first instance because, when the apparatus was first brought out, steel cylinders for compressed gases were unknown; copper also is the favourite metal of submarine engineers, being able to withstand the corrosive action of sea water so much better than steel, and possibly this may to some extent explain why copper is still used. The copper cylinder exhibited measures 6 inches in diameter and 15 inches long over all, charged with gas and including the carrying straps its weight is over 20 lbs., and at a pressure of about 400 lbs. to the square inch it contains oxygen equal to about 4 cubic feet, a quantity sufficient to last for three or four hours' breathing.

The total weight of the apparatus with the copper cylinder all ready for use is 30 lbs., and the cost is about £13 per complete set.

The Apparatus in Use.

To use the apparatus the cylinder is first strapped to the back by means of the belt and shoulder straps, next the bag is placed in position in front, it already having been charged with 4 lbs. of caustic soda.

The small rubber tube from the valve of the oxygen cylinder is connected with the corrugated inspiration tube, both the corrugated tubes are connected to the mask and to the bag, and the mask slung round the neck in readiness to be adjusted. The person then enters the mine and advances

until the atmosphere shows signs of being impure, when he adjusts the mask, at the same time turning the oxygen valve to admit oxygen to the bag, this valve is closed again as soon as the bag is sufficiently distended. Breathing then proceeds naturally, the air is drawn into the lungs, a portion of

Fig. 2.

THE IMPROVED "FLEUSS."

Showing the Mask, Tubes, and Breathing Bag.

the oxygen converted into carbonic acid which is exhaled into the bag together with the unaltered nitrogen, coming in contact with the caustic soda, the carbonic acid is absorbed by it, and in this way the breathing continues until the bag begins to show signs of getting "flabby" from loss of oxygen, more of the latter is then admitted, this being

necessary about once every ten minutes. The oxygen is not admitted in a continuous stream, but intermittently, the idea is to keep the bag distended between a certain minimum and maximum, when the proportion of oxygen present will be such as to properly sustain breathing. It perhaps ought to be remarked at this point that the atmosphere which the person breathes consists of oxygen and nitrogen, in which

Fig. 3.

SHOWING THE OXYGEN CYLINDER AND STRAPS.

the former is always slightly in excess of the proportion which is present in the normal atmosphere, and its proportion is not constant, but varies; when first oxygen is admitted, and the bag distended to the maximum extent, the percentage of oxygen breathed is above that in the normal atmosphere, and this gradually diminishes until the proportion is just above normal, when more oxygen is admitted. The breathing of this slightly excess quantity of oxygen is not harmful or dangerous.

The Suggested Improvement.

It will no doubt be thought that even in its present form the appliance is still too heavy, and more particularly too bulky, for use in mines where the roadways are small and possibly may be fallen up. The heaviest and most bulky part of the apparatus is the oxygen cylinder. There is, however, apparently no reason why the copper cylinder should not be replaced by a steel one. A steel cylinder is exhibited in connection with the apparatus, from which it will be seen that the appliance at once becomes a more practicable mining appliance. The steel cylinder contains a quantity of oxygen equal to 6 cubic feet, of course at a higher pressure; its weight is slightly over 10 pounds, and it measures 4 inches in diameter, and 13 inches long over all. These cylinders are made of the very best quality mild steel, carefully annealed before use and at intervals during use afterwards. The cylinders are weldless, and are tested by hydraulic pressure to a pressure of 1½ tons per square inch.

It will thus be seen that while a copper cylinder weighing 20 lbs., and measuring 6 in. by 15 in. contains about four cubic feet of oxygen, a steel cylinder of slightly more than half the weight and less in bulk will contain six cubic feet. It is not suggested that this larger supply will enable a man to use the apparatus for longer periods, but the excess might very possibly be of great value for the purpose of restoring animation and saving life.

Dr. Haldane states that the best remedy in the event of carbon-monoxide poisoning is the administration of pure oxygen. A steel cylinder of six cubic feet capacity might be provided with an additional valve and a short piece of rubber tube, and by this means the additional supply of oxygen could be applied for the purpose named, at least two cubic feet would be available, and the Fleuss as a life-saving appliance would thereby be considerably increased.

A Safety Lamp to use with the Fleuss.

Of course, it will be evident that an atmosphere in which it is necessary to use the Fleuss apparatus will not permit of an ordinary safety lamp being used. Mr. Fleuss got over this difficulty by providing a lamp which, like the Fleuss apparatus itself, carried its own oxygen supply. Without going into the details of the lamp, it is sufficient to say that it was very unsuitable for use in a mine, especially where the roads were likely to be fallen, it was very heavy and very bulky.

The writer exhibits an electric safety lamp which he has for some time used in the mine, and which could be used in connection with the Fleuss apparatus. It consists of a small six cell accumulator, made at the Bristol Electric Safety Lamp Works, which may be attached to the belt or shoulder strap of the apparatus. A short piece of twin flexible wire connects the poles of the battery with a small incandescent lamp which the writer always wears in the neck of his pit shirt when using the lamp. It gives a light equal to four of the best ordinary safety lamps for a period of five or six hours, the light is well distributed on both sides, on the roof and floor, as well as in front. There is no heat from the lamp, and in weight is just about equal to the average Marsaut, but it has the great advantage that both hands are left free.

The Fleuss Apparatus at Established Centres or Stations.

In several colliery districts at the present time, in addition to the first aid appliances kept at the collieries, there have been established at convenient central places in the districts, a complete outfit of appliances and a horse ambulance for the easy removal of injured persons. In every colliery district also, classes are conducted in connection with the St. John Ambulance Association, and these classes are well

attended. Would it not be possible to include at the stations above-named two or three sets of the Fleuss Apparatus as part of the first aid appliances. No difficulty would be found in getting men to come forward to be trained in the use of the apparatus, it would always be in readiness for use, and in the event of a colliery explosion a trained rescue party could be quickly on the scene of the disaster, not only willing to enter the mine, but what is far more important, able to do so without waiting until ventilation is restored, during which time the very gases which prevent their access to the mine are bringing about the death of those whom they would save. Over and over again has it been shown that lives might have been saved had it been possible to enter the mine without delay. The writer cannot see why trained rescue parties provided with the necessary appliances should not be established in every colliery district, just as are fire brigades in all thickly populated localities. A fire brigade would never think of turning out to a fire without the necessary appliances, the pumps, hoses, fire escapes, &c., and yet in the event of an explosion at a colliery, in these days of enlightenment and science, those who nobly offer themselves to form the exploring party enter the mine without any protection for themselves, and absolutely unprovided with anything of the nature of a life-saving appliance.

The President moved a vote of thanks to the author for the trouble he had taken in bringing before them and explaining the Fleuss Apparatus.

Mr. Barrett seconded the motion, observing that anything done with the object of assisting in saving life ought to be encouraged in every way.

The motion was unanimously carried, and Mr. Winstanley having responded a short discussion followed.

Mr. Harrison said he had often wondered why the apparatus had not been adopted more generally in mining districts, even in its original cumbersome form. It cost a fair sum, but that, to the average coalowner, was not a thing which should be thought about. It would be a very easy matter for collieries round Wigan to have a few of them at some central station. That might be done, if every individual coalowner did not provide one for himself. In fact, considering the few times they would be required, it was needless for coalowners to have one each. Cases had often arisen where it was evident that if one or two men had gone down the mine immediately after an explosion, many lives might have been saved. At Micklefield a man had been picked up alive two or three days after the explosion and taken to the hospital, where he lived for about 24 hours. In that case if something like the Fleuss Apparatus had been available the man might have been picked up earlier and his life saved. There were many other similar cases. With regard to Mr. Winstanley's improvement this would considerably reduce the cost of the appliance, as in its present form the copper cylinder made up such a large proportion of the cost, that the substitution of the steel cylinder would mean a reduction of some pounds in the price. A greater advantage even than the reduction of weight would be the reduction of bulk (as was pointed out by my colleague, Mr. Saint, in a discussion on the paper read at a meeting of colliery managers held in Manchester), for it would be much less difficult when the explorers had to crawl over falls in contracted spaces where it would be dangerous to touch any loose stones. He was sure if the matter was only properly brought before colliery owners the appliance would be taken up at once.

Mr. Stirrup said that in the Fleuss Apparatus the weight

seemed to be an objectionable feature, but the adoption of the steel cylinder would reduce that considerably.

Mr. Mort referred to a statement by Dr. Haldane to the effect that there was no practicable absorbent of carbon monoxide—the chief dangerous element in after-damp. Hæmoglobin was an absorbent, but was of course impracticable. It was a pity there was no easily obtainable absorbent that would make the after-damp respirable.

Mr. Hall said the Fleuss Apparatus was an old friend, and many years ago had been put before a meeting of the Mines Inspectors, who had to report upon it. The conclusion they came to was that which would probably be arrived at to-day—that if it was to be of any use the men using it must be skilled professional Fleuss men, just the same as divers were professional divers. There was no reason why they should not have paid skilled men, and have a station where the apparatus could be kept. Mr. Winstanley had said that after an accident the men were sent down, or volunteered to go down, very much at random. That was not so. The men were under some kind of regulation. The general idea of a good regulation was to keep the air with you. They must carry the air forward as they proceeded. The question was whether it was better to carry the air forward as they went, so that they had the fresh air with them to restore animation, or to leave the air alone and proceed by means of a Fleuss Apparatus.

Mr. Gerrard observed that it went without saying that if anything could be done to save life it ought to be adopted. The apparatus could, however, only be used by skilled persons, who should be expert not only in the use of the appliance, but also in travelling underground; they should be well acquainted with the mine they were to explore.

Mr. WINSTANLEY, replying upon the discussion, said the complete apparatus cost £13 per set, and the steel cylinder, if adopted, would probably reduce the price. Certainly skill was necessary in using the apparatus, but it was not very difficult to get into the way of using it. It should be easy to teach members of ambulance classes to use it. Certainly it would be better if they could have mining men to use it. He had not wished, in his paper, to infer that exploring parties did anything at random or without due care. What he meant was that they were absolutely unprovided with anything more than if they were ordinarily working. They had no live-saving appliance with them. It was very important to get at the imprisoned men quickly. A small percentage of carbon-monoxide produced insensibility, which was followed by death unless the sufferer was taken quickly into the pure atmosphere.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART VI. VOL. XXV. SESSION 1896-97.

The ORDINARY MEETING of the Members was held on Tuesday, February 9th, 1897, at the Society's Rooms, Queen's Chambers, John Dalton Street.

The President, Mr. MARK STIRRUP, F.G.S., in the Chair.

NEW MEMBERS.

The following gentlemen were balloted for and duly elected Ordinary Members of the Society :—

Mr. EVELYN G. HOWSIN, Huntroyde Estate Office, Padiham.

Mr. FREDERICK LEES, Colliery Proprietor, Alkrington Mount, Middleton.

Mr. EDWARD ALLEN, M.E., Willow Bank, Peel Causeway, Bowdon, Cheshire.

Mr. JOHN WHEWELL, jun., Land and Mine Surveyor, Sharples, Bolton.

GIFTS TO THE LIBRARY, AND NOTICES.

The PRESIDENT said : Before calling upon the gentlemen who are to contribute papers, I wish to make one or two announcements. The first is that I have received a contribution to the Library from M. Martel, the gentleman who has for some years past been exploring underground caverns in various parts of Europe, and who in 1895

visited Ireland for the same purpose, and also explored some caves in Yorkshire, including that known as Gaping Gill. He has sent a copy of his work, "Irlande et Cavernes Anglaises," in which is contained an account of these English and Irish explorations. It is beautifully got up, and contains some charming photographs of Irish scenery. There are also included sundry pamphlets and extracts of contributions which he has made to the Academy of Science in Paris, and other learned Societies elsewhere.

I have also been asked to remind the members of the forthcoming International Exhibition, which is to be held at Brussels during the current year. The interesting point about this, to us, is that the Belgian Government is organising a section of pure and applied sciences, and the General Commissary of the Government has sent a pamphlet containing all the particulars and conditions which have been laid down.

There will be a section devoted to Geology and Geography, where photographs, models, specimens, maps, fossils, and minerals may be exhibited, and to which the Society is specially invited to contribute.

In addition, several money prizes are offered for memoirs tending to the solution of scientific problems, such as the following, in the Class Geology :—

1. To set forth in one or more special coal-basins, the geological phenomena which tend to explain the geogeny of coal, and to state the geological and palæontological observations which may guide in the foundation of the synonymy of coal beds.

2. To establish the level where the limit between the Devonian and Carboniferous should be placed.

I have also to report that Mr. Dickinson has been kind enough to present to the Society a general section of the Lancashire and Cheshire coalfields. The date of the Chart

is 1858, but it will nevertheless be of very great value to members interested in mining. Perhaps Mr. Dickinson may have some remarks to make upon it. He has been asked if he would bring it up to date, and has promised to do so provided he can secure the requisite assistance from gentlemen who may have sections in their keeping.

Mr. Dickinson: I shall be very happy to bring the chart of sections up to date. If the coalowners and mining engineers, who have the information, will be kind enough to give it to me, I will take the trouble to put it into shape.

ON THE HISTORY OF THE DISCOVERY OF THE SOUTH-EASTERN COALFIELD.

By Professor Boyd Dawkins, F.R.S.

The paper recently read (July 14th, 1896) before the Federated Institution of Mining Engineers, by Messrs. Brady, Simpson, and Griffiths, on the Kent coalfield, raises the question of the discovery in such a manner that it is necessary to bring it before the Manchester Geological Society, to whom the results of the work were communicated by me in a series of papers printed in the Transactions. In the paper above referred to, the sole credit of instituting the boring is assigned to Mr. Brady, the Engineer of the South-Eastern Railway. If the account there given be true, my papers read before the Society are untrue. As one of the prime movers it becomes my duty to record the facts without further delay, while all those who are concerned in the matter are alive, and while all the documentary evidence is to hand. The importance of the discovery raises the matter above the level of an ordinary difference of opinion, and its probable far-reaching results

in the future, lend a value to personal details otherwise dull and unprofitable. It is, indeed, a matter not of opinion, but of fact.

The physical identity of the coalfields of Somerset with those of northern France and Belgium, was recognised by Buckland and Conybeare as far back as 1826, but it was not until 29 years later that Godwin-Austen in his memorable paper, "On the Possible Extension of the Coal Measures beneath the South-Eastern part of England," advanced the view that coalfields within workable distance were buried beneath the oolitic and cretaceous rocks of the southern counties.

The next stage in the development of the question is that marked by the Coal Commission of 1866-71, before whom Godwin-Austen gave evidence. Prestwich, one of the Commissioners reviewed all the facts in an elaborate report, and finally concluded that the Coal Measures of Somersetshire and of northern France and Belgium were represented in south-eastern England by long narrow east and west troughs, concealed beneath the newer rocks. The publication of this report in 1871 helped the question largely towards the experimental stage. It bore fruit in the next year in the organisation of the Sub-Wealden Exploration Committee,* by whom a bore-hole was made in a spot selected by Mr. Henry Willett and myself, at Netherfield, near Battle. The boring ended in the Oxford clay, and proved that the oolites are more than 1,700 feet thick in that place. It also followed, from the great additional thickness of the Wealden rocks forming the surface of the ground between Netherfield and the Downs, both north and south, that it was not advisable to make another trial boring in the southern area of the Weald.

* The committee consisted of Professors Ramsay and Phillips, Sir John Lubbock, Sir Philip Egerton, and Messrs. Hawksley, Warrington Smyth, Prestwich, Bristow, Etheridge, Boyd-Dawkins, and Willett.

The question was further advanced during the next eleven years by the borings in and around London, which revealed the absence of the Wealden rocks, and the extreme thinness of the oolites, and proved that the buried floor of older palaeozoic rocks was not more than 1,200 feet at most below Ordnance datum. Prestwich too, had pointed out in 1873 that they were probably sufficiently near the surface at Dover for the making of a submarine tunnel. It was therefore obvious that the area of the North Downs offered the best position for a fresh attempt, where both oolites and wealden strata thinned off against "the axis of artois."

Mr. Henry Willett and myself were so strongly of this opinion, that we arranged in 1884-85 to put the matter to a practical test somewhere in the neighbourhood of Dover. This was also the opinion of Mr. Whitaker in 1885. The work, however, which we intended to do, purely as a matter of scientific enquiry, was undertaken on a commercial basis, and under the following circumstances.

In the course of my work (from 1882 onward) as scientific adviser to the Channel Tunnel undertaking, I had to examine in minute detail the parts of France and England immediately surrounding the two ends of the proposed tunnel. In the spring of 1886 I was requested to report to the Chairman and the Directors of the South-Eastern Railway, upon the advisability of boring in Kent, at a spot between Tunbridge and Godstone, proposed by Mr. Taylor. In that report I pointed out the importance of the coal question to the Company, and the desirability of having it definitely settled by boring. I was then requested to report on the general question of the existence of coalfields in the south-east of England. I recommended that the site of the Channel Tunnel Works at the Shakespeare Cliff, Dover, was the best place for an experimental boring (Report, April 7th, 1886), "to prove the westward extension of the Calais

"measure, which, it must be noted, are only twenty-seven "miles to the east.

"The older rocks there will probably be struck at a depth "of less than one thousand feet from the surface, probably "very much less. The probability that the Coal Measures "will be struck in this district, is rendered greater by the "discovery of a large mass of bituminous mineral in a "fissure in the chalk to the north of Dover, that has "probably, as Mr. Godwin-Austen points out in his evidence "before the Coal Commission, been derived from the Coal "Measures below.

"If the Coal Measures are proved, a discovery of vast "importance will be made. If, on the other hand, rocks "older than the Coal Measures be struck, they will offer a "basis for further borings by private individuals, which will "ultimately result in their discovery, and cause an economic "revolution in south-eastern England, as great as that "which has been brought about by the working of coal "under the chalk in France and Belgium."

This report was acted upon at once, and I was retained by Sir Edward Watkin to undertake the geological supervision of the enterprise, and to obtain estimates from various firms as to the boring, which ultimately was put under the charge of Mr. Brady. In the matter of boring we had also the advice and assistance of Mr. Pigou.

From this time down to 1891, the duties of examining the cores, identifying the fossils and rocks, and of reporting geological progress to the Chairman and Directors of the South-Eastern Railway, and of the Channel Tunnel Companies fell to me. This, of course, implied continual attention and periodic visits to London and Dover during all those years, including an examination of the coalfields of the Boulonnais and the Pas de Calais.

With the discovery of the coalfield in 1890, the further prosecution of the work was merely a question of sinking deeper, and of testing the commercial value of the seams which had been discovered, and of practical mining. On these points the advice of Messrs. Bainbridge, Tylden Wright, McMurtrie, P. S. Reid, and M.M. Victor Watteyne and Breton was sought. In this stage of the enquiry I had little share, because it was merely a question of practical mining. With the following report my connection with the enterprise ceased :—

1st July, 1891.

COAL AT CHANNEL TUNNEL WORKS, DOVER.

Having carefully considered the general question, and examined the sections, and the several samples of coal that have been obtained, we are of opinion that the evidence in favour of workable coal is sufficient to justify a trial shaft being put down immediately on the site of or near to the present boring.

W. Boyd-Dawkins,
C. Tylden Wright,
Fras. Brady.

The responsibility for the conduct of the geological part of the enterprise was mine, the higher responsibility of carrying out the work to a successful result was Sir Edward Watkin's, while Mr. Brady acted under his instructions in charge of the actual boring. *Qui facit per alium facit per se.* To Sir Edward Watkin is due the credit of translating geological theory into ascertained fact. With the geology Mr. Brady had nothing to do.

While the work was in progress I was authorised to publish from time to time the results. This was done before the British Association in Manchester (1887), and in Cardiff (1890), the Royal Institution (June 6th, 1890), in the columns of Nature (March 6th, 1890), and the Manchester Geological Society (Transactions Vols. XX., 1890 ; XXI., 1893; XXII.,

1894). I also brought them within the common knowledge of the public in an essay in the *Contemporary Review* (April, 1890), in *The Iron and Coal Trades' Review* (March 7th, 1890), and the *Colliery Guardian* (June, 1894).*

It is difficult to understand how this body of literature could have escaped the notice of the authors of the paper read before the Federated Institution of Mining Engineers, which gives occasion to this communication.

From the admission of Mr. Griffiths in the debate, it appears to be due to the paper having been prepared solely "from material supplied by Mr. Brady." In it, not only is my share in the work passed over in silence, but even Sir Edward Watkin is relegated to a subordinate place. The claim is set up that the boring was "instituted and superintended by Mr. Brady, with the co-operation of Sir Edward Watkin." It was not "instituted" by Mr. Brady, but by Sir Edward Watkin.

We are also told that Mr. Brady suggested in 1882 to Sir Edward Watkin, "that the coal question could be tested by "him with the men retained under him to maintain the "Channel Tunnel works; and the coal-boring was eventually "authorised accordingly." The suggestion was still-born, was not acted upon, and as I have shown above, had no share in the "institution" of the enterprise. The claim may safely be left without further comment to the judgment of those who are interested in the discovery.

It only remains to add that the questions as to who did the work and undertook the responsibility, are small in comparison with the discovery itself, in which the geological faith of Godwin-Austen and Prestwich had resulted in works which will add sooner or later a new centre of industrial activity to the resources of this country.

* The communication will be found under the above dates.

Mr. R. WINSTANLEY said: I have great pleasure in moving a vote of thanks to Professor Dawkins for his communication; and I should like to remark that the Professor's explanation has been, in justice to himself, rather too long delayed. Members of this Society who have had the pleasure on more than one occasion of listening to his communications on the subject of the south-eastern coalfield, and who saw the valuable sections of the boring, at one of the evening meetings at Owens College, with samples of the coal passed through, and of the fossils discovered, were very much astounded at the meeting of the North of England Institute, not to hear his name mentioned at all. I sat next to my friend Mr. Dickinson at that meeting, and expressed my surprise to him; and Mr. Dickinson, in his speech, made the inquiry why Professor Boyd-Dawkins had been ignored. As we have heard Mr. Griffiths, in his reply, apologised, and said that the information had been supplied by Mr. Brady. It was certainly a matter of surprise to us, and to many others outside, who knew the valuable work which Professor Dawkins had carried on.

Mr. JOSEPH DICKINSON: I have much pleasure in seconding this vote of thanks to Professor Boyd-Dawkins. I may say that I fortunately happened to be present at the Wigan meeting, when the paper was read by Mr. Griffiths, in which to my amazement no mention was made of Professor Dawkins. I at once called attention to the omission, as will be seen from the published report of the proceedings. I said: "Professor W. Boyd Dawkins, whose name was not referred to in the paper, had done so much in enlightening members on the subject that they should not pass it over without mentioning his name."

Apology was at once made by Mr. GRIFFITHS, for the omission of Professor Dawkins' name, who said that it was

entirely his own fault, as he had prepared the paper from material supplied to him by Mr. Brady. I am very glad that my impromptu remark has brought this matter to a final conclusion, and led to the establishment of the true authorship of this discovery. It is a matter of justice to Professor Dawkins that his work should be acknowledged, and I am very glad that I was instrumental in getting the matter explained at the time.

The PRESIDENT put the resolution to the meeting, and it was carried unanimously.

The PRESIDENT: I may say, so far as I am concerned, this matter has come upon me as somewhat of a revelation. Until I heard Professor Dawkins' paper and the explanations of the mover and seconder of the resolution, I had not the faintest idea that Professor Dawkins' work in connection with the Kent exploration had ever been questioned. It is, I take it, matter of history. The names that have been put before us—Godwin-Austen, Prestwich, and others—were well-known leaders in that line of enquiry, which, founded on personal observations in the coal-basins of Belgium and Northern France, led to the propounding of a theory of the probable extension of the coal deposits to the south-east of England; their opinions, founded on theoretical considerations, had been before the scientific world for years, and it was the borings so gallantly undertaken by Sir Edward Watkin, whose coadjutor and scientific adviser Professor Dawkins was, that proved what had been previously surmised to be the actual fact, namely, that valuable seams of coal existed in the county of Kent. I am sorry to find that there should have been any desire to ignore Professor Dawkins' part in that discovery. Whether it was due to a simple omission, I know not, but the fact is certainly curious, that at a meeting of a Society of such weight as the North of England Institute of Mining

Engineers, such an omission should have been made. The facts had long been before the public. They were indisputable, and it was a surprise to me to find Professor Dawkins' claim apparently contested.

Mr. WINSTANLEY: A portion of the paper read at Wigan has been copied since, in a recent publication, without any reference to Professor Dawkins.

The PRESIDENT: It is very irregular, to say the least, because it is usual in scientific circles to acknowledge all priority in works of that kind. I do not know whether Professor Dawkins is in a position to say how the work is progressing at Dover.

Professor BOYD-DAWKINS: I am afraid I cannot give you any information as to what is going on now, for I have not been down to the place for a couple of years.

Mr. HOLROYD: I understand that they have met with a quantity of water in sinking.

Professor BOYD-DAWKINS: I cannot answer as to that, but I should think it not at all unlikely.

Mr. DICKINSON: I should like to say for the information of some of the practical men present, that Mr. Griffiths' paper contained some exceedingly useful information. It was accompanied by a detailed section and samples of the cores brought up, and one fact was that the stratification was found to be horizontal. The thickest seam of coal yet proved is 4 feet of good bituminous coal, at a depth of 2181 feet 6 in. below sea level.

Professor DAWKINS replied to the vote of thanks.

The PRESIDENT said the next communications to be read were by Mr. William Watts—first, on the earthquake of December, 1896; and secondly, on the recent bog slide in Ireland.

EARTHQUAKE TREMORS.

By Mr. William Watts, F.G.S., Member of the Municipal and County Engineers, &c.

The earthquake tremors which shook the greater part, if not the whole, of England on the morning of the 17th of December, 1896, aroused wide-spread interest in every scientific mind, and information has been sought in every corner of the island with a view of tracing the path of the movement and its intensity. Shocks of the kind to which we were treated on the morning named are happily rare in England.

Having long desired to experience the strange sensation of an earthquake, I had the satisfaction during the late movement of feeling it, although I was unconscious of the phenomenon at the time. I was asleep in bed and the shock awoke me, and for about five seconds I was under the impression that someone was walking about in my bedroom and I jumped up to see who it could be, but saw no one, and left my room to examine the landing to find all silent there. I concluded, therefore, that I was mistaken, and thought no more of the matter until I saw in the papers many accounts of an earthquake shock having shook the whole of England. No ornaments or pictures jingled in my room, but the vibration was clear and pronounced, and in my opinion there were four or five backward and forward movements. My residence is situated on one of the buttresses of the Pennine chain, inclining south-west, and at an elevation of 770 feet above the sea level.

The shock seems to have been very generally felt, and occurring as it did at 5-33 a.m., many people were stirring to prepare for the day's work.

Professor Milne, and other scientists, have asked for information hereon, and I thought the above remarks might be of interest to the members of our own Society, and probably would find their way to Professor Milne and others through the learned societies with which we exchange transactions.

NOTES ON THE RECENT SLIPPING PEAT IN IRELAND.

By Mr. William Watts, F.G.S., Member of the Municipal and County Engineers, &c.

The slipping of extensive peat bogs is a rare phenomenon, and does not often destroy life and property as the one which recently aroused public attention and sympathy, in Kerry, Ireland. Peat is vegetable matter and grows slowly, and water is essential to its life. Too much or too little water checks its growth. It never attains a great thickness on sloping ground, and swampy places have less fibrous material in them than the drier, hence the "meres" or pools of stagnant water so common in boggy land. A healthy condition of peat life depends on favourable climatic conditions, below rather than above the mean temperature. Rain water supplies the bog plants with nourishment more favourable to their growth than subterranean supplies, and it seems necessary that the floor on which they repose should be impervious to water.

Spring water, from subterranean sources, does not rise up in the peat to feed the living tissues at the surface, but it descends very slowly to a slight depth only, the bulk of the water draining off at the surface. It is this condition, added to its spongy character, which makes it so wet to walk on. If spring water spread extensively over the floor

of a bog, it seems to the author that it could not attain a depth of more than a few feet, as the whole of it would be carried away as the fibrous matter decayed and lost its coherency. It is very little heavier than water, and in its rotten condition becomes loose and friable with slight motion. This, however, is the author's experience of bog land, and he has no reason to suppose that the behaviour of peat in Ireland acts differently. These views are at variance with those of Professor Sollas and others in their investigations of the Kerry bog flow, but he simply gives the results of his own experience obtained on the moors and in the valleys of the Pennine chain. As a rule all bogs lie on an impervious floor, of generally a white pasty clay, overlying shale, which the acid water has bleached and helped to dissolve. It is soluble in water and becomes mud when placed in a bath. Pasty clay readily lends itself as a lubricating material when once started on an inclined surface. It is not, however, absolutely necessary that the surface of the ground on which the peat has grown should be steep to induce slipping. Depth is the primary factor to set it in motion. The author has seen peat slip on level ground and plough up wagon roads, and bury them, when the thickness of the fibrous matter has been no more than 16 feet. The movement invariably takes place during, or after, a wet period, and he is of opinion that an earth tremor, or strong winds, have nothing to do in starting the flow, but may aid it when in motion. Wet periods are more favourable for the movement of peat than any other cause, especially when they succeed dry summers, when the ground is cracked and opened out by evaporation. Spongy peat, such as that which can be cut with a spade, contains 53½ lbs. of water to the cubic foot, and 8½ lbs. only of solid substance. The weight varies, however, according to the wetness or dryness of the material, being heavier when it

contains less water, sometimes reaching 75 lbs. to the cubic foot.

It seems incredible that fibrous and fragile rootlets are able to hold in suspension 53½ lbs. of water in the space of a cubic foot, but the author has measured and weighed samples and knows the information to be reliable. A cubic foot of water weighs 62½ lbs., therefore 9 lbs. of solid peat are able to retain 53½ lbs. of water.

The amount of water held in suspension is less as the depth of peat increases, but none of it is waterless. The bottom layers are rotten and friable, and will not hold together the same as the tough fibrous matter at the top, and in commencing to move the bottom slides away first and when undermined the top falls in, and, in this manner, the whole bed moves slowly away from its mooring, and in doing so breaks up into smaller pieces as represented on the diagram. As the bottom shoots outwards, the top falls back terrace-like, leaving openings at every step into which water accumulates and acts as a hydrostatic wedge exerting a force in proportion to its depth. Rotten peat needs very little breaking up for the water to get hold of it, and carry forward in suspension and become a semi-liquid. The bottom layers of peat are prone to this condition, and the author believes that under the conditions herein named, water more easily moves forward friable peat in suspension than "snow broth" in an open stream. The living fibres hold together very tenaciously, as may be seen in most mountain gullies, by the sods overhanging the sides.

The secret of the slipping of peat bogs is to be looked for in the hydrostatic pressure and onward flow of the water which they retain. Peat cannot go on accumulating *ad infinitum* any more than glacier ice. Its own pressure must force it forward in time, and the process is repeated at slow intervals, hence we see so little of them. The author has

seen three small peat bogs slip away from their moorings, and he has described them to the best of his knowledge. The movement is always very slow, not more than 1½ to 2 miles per hour even when fairly well charged with water. When confined in a narrow valley, and steeped in the water of the stream, the material rolls where it is lumpy, and slides where it is semi-liquid. It adapts itself, more or less, to the conformation of the ground, and rises a little higher than the side of the valley, being influenced by friction in this respect.

Few moving bodies are more interesting to watch. Silent in motion, slow in movement, they gather round an opposing object before one is aware, and unrelentingly cling to it and bury it on the spot. Peat parts with its water very slowly, which is one of its characteristics, and makes it troublesome stuff to deal with. Under pressure it is practically water-tight, and the author has seen puddle trenches made of it. Bog flows are sometimes attributed to the bursting of a cloud, and the first one seen by the author he followed to its source to find the true cause to be what he has attempted to describe. These remarks are offered for what they are worth, and it is hoped that other members will throw additional light on the subject of flowing bogs.

The thanks of the meeting were given to Mr. Watts for his communications, on the motion of Professor Boyd Dawkins, seconded by Mr. Gerrard.

Professor Boyd Dawkins: I understood Mr. Watts to say that the highest part of the bog was in the middle of the valley—that would be about the stream, I take it.

Mr. Watts: Yes.

Professor Dawkins: I can explain that by my experience of a bog in Somersetshire. In the winter time, looking across the morass, you would fail to see certain old houses

on the other side which during the summer were plainly visible. That was because, in winter, the rains had caused the surface of the peat to rise between the point of view and the old farm house three or four miles away. The centre is highly charged with water, and therefore swollen.

The PRESIDENT: I think it is a common experience, with regard to our Cheshire bogs, that in the winter time, when swollen with rain, they rise in the centre, and if you stand at one special point at one time you may see further than it would be possible to do at another time. It is simply explained in that way—that the bog is expanded by the quantity of water that is absorbed by the masses of sphagnum and other vegetation in the bog. Did I understand Mr. Watts to say that all bogs are on impervious floors?

Mr. WATTS: That is my experience.

The PRESIDENT: Because it was said, with regard to that Kerry bog, that the rock underneath it was channelled with water-courses; the fissures in the limestone rock had got filled up, causing an excess of water in the mass of the bog, which could not find an issue in the ordinary way.

Mr. WATTS: Wherever water lingers there must be an impervious floor. You cannot possibly—speaking from my own experience—have water moving and peat remaining behind. The peat must go along with the water.

The PRESIDENT: The bog is held together by fibrous vegetable matter, rootlets of plants, sphagnum, &c., &c., the tension thus created is overcome by the force of the water. Attention has been prominently called to this question by the bog slide in Kerry, but the movement of bogs under certain conditions is not unknown in Ireland, or even Lancashire. During the excavating of the Ship Canal, it was found that into the old bed of the river Irwell there had been some old bog-slips. These things are always

taking place more or less, and when there has been an excess of rain, as in the recent case, they are liable to take place on a large scale.

Mr. R. SUTCLIFFE: I would like to ask Mr. Watts whether he has observed that in the course of its movement the peat has got pulverised. I remember during the coal famine 23 or 24 years ago—at which time I lived in Ireland—some friends of mine made experiments with the view of converting the peat into artificial fuel. They found when they tore the peat assunder—that is to say, pulverised it—and let it dry, it formed a first-class peat fuel, having very nearly the density of coal. It was, in fact, harder than many coals, and was found useful for a variety of purposes.

Mr. HOLROYD called attention to the samples of compressed peat which he exhibited and described at a former meeting, and which he thought the last speaker might not have seen.

The PRESIDENT said the specially interesting part of Mr. Watts' paper was that relating to the flow.

Mr. DICKINSON: In the Irish bog flow I see it stated that about a million cubic yards moved, carrying away not only the farm house, but trees, hedges, and whatever intervened. It must have caused something like what was found in the cuttings for the Ship Canal. I examined most of them, and was very much struck with the character of the *débris*. There were stems of large trees, many of them over four feet in diameter, and stones rounded and worn of various kinds, which had been carried along by some moving force. Many people attribute such phenomena to the action of ice during what is called the glacial period, but it appears from what we have heard, and the descriptions given of the character of the movement in Ireland, that such movements may occasion both striæ and other appearances which have hitherto been attributed solely to ice action.

The PRESIDENT: Have you any case in point where striæ have been caused by the movement of peat?

Mr. DICKINSON: I have not the slightest doubt that the movement of a million cubic yards, as is stated to have occurred in Ireland, would produce striæ.

The PRESIDENT: It would make hollows, no doubt, but what we understand by striæ is furrows or grooves in hard rock.

Mr. GERRARD: It is not the water, but what the water carries—and so, in this case, it is not the peat but what is carried along by the peat—that would do it. I see from the *Irish Naturalist* that the three learned gentlemen who went from Dublin to investigate the Kerry bog slide have prepared a report. They speak of three causes as having contributed to the disaster. First, earth tremors; secondly, underground springs; and lastly, a strong wind which was blowing, I think, from the south-west.

The PRESIDENT: There is no evidence that earth tremors had anything to do with it.

Mr. WATTS gave some further explanation of his diagram, illustrating the action of a bog in motion. It is not, he said, possible for peat to move unless the bog has an open end. It must have that to start it. In summer, as you know, water is evaporated out of the peat very extensively, and as the water occupies space, when the evaporation is effected cracks are left in the peat, which, when heavy rain comes, get filled with water, and the moisture percolates down to the friable peat at the base. Then, if there happens to be an open end whether on the level or on an incline—though more readily, of course, on an incline—the peat, if it is of sufficient depth, begins to move, the lower stratum, having been made friable, falling away in the manner I

have described. There is another idea. Anyone who has walked over the moors will occasionally have put his foot into one of these openings. When an opening is once made, and becomes filled with water, it rarely ever closes again so as to be as solid as the original bog. You find it slippy and nasty. I have sometimes been up to the middle in one of those treacherous places. There is too much water there for the living bog to grow and knit the sides together. That is an important thing to bear in mind in considering the beginnings of the movement. With regard to the solidity of peat, I think that is pretty well understood. Very recently we have been taking away an old pit head. We sank a shaft 150 yards deep in one of our tunnels fifteen years ago, and the *débris* from this shaft was poured on a peat bed, and in consequence of some new works going on we have had to shift it into the embankment. We found the peat extraordinarily condensed, but I must confess I could not fancy it condensed as hard as some of the samples referred to by the last speaker. I have also seen peat used as a substitute for puddle in puddle trenches, and I should not hesitate for a moment to use it in that way if the trench were not of great depth. Caution, however, is necessary. In order to make peat water-tight it has to be cut and worked precisely as you would work and cut puddle. If you do that, and let the pressure squeeze out the water, you may rely upon it you will have a very good peat core for a reasonable depth. I think these observations cover fairly the questions which have been asked. I may say that I was induced to write these notes through reading the account of the Kerry bog slide, and as we have recently removed 140,000 cubic yards of peat from a new reservoir bottom it will readily be understood that I have seen something of it.

ON EVIDENCES OF GLACIAL ACTION IN AUSTRALIA.

By Mr. Bernard Hobson, M.Sc., F.G.S.

The following notes abstracted from the paper "Evidences of Glacial Action in Australia in Permo-Carboniferous Time," by T. W. E. David, B.A., F.G.S. (*Quart. Journ. Geol. Soc.*, Vol. 52, 1896, pp. 289–301) were read by Mr. B. Hobson, M.Sc., F.G.S., in explanation of some specimens of Glaciated Rocks from Australia, exhibited by Prof. W. Boyd Dawkins, which were presented to him by Prof. David :—

The first actual record of evidence of ice-action in Australia is probably that made by Dr. A. R. C. Selwyn, in 1859. He records a smooth, striated, and grooved rock surface in the river Inman, in South Australia (between Cape Jarvis and Mount Serle).

The chief localities in Victoria are Bacchus Marsh (west of Melbourne), and south of the main dividing range of Victoria), and Wild Duck Creek, Derrinal, near Heathcote (to north of the main dividing range). At Bacchus Marsh we have—

1. Lower Silurian (Ordovician), black slates and shales with graptolites, and grey quartzites intruded in places by granite. Wherever their surface has been freshly exposed in the neighbourhood, it is seen to be strongly grooved and polished, and more or less *moutonnée*. Mr. David agrees with Sweet, Brittlebank, Graham Officer, and Balfour, in holding that the ice came from the south. At the Werribee Gorge the striæ trend from about S. 12° W. to N. 12° E.

Overlying the Lower Silurian rocks at Bacchus Marsh, are the Permo-Carboniferous Glacial Beds. The total measured thickness in Korkuperrimal Creek is 1,427 feet to the bed, at top containing the fern Gangamopteris,* to which should be added another 700 feet to the top of the strata seen above the horizon containing Schizoneura. At Bacchus Marsh there are from nine to ten distinct boulder-bed horizons (consisting of hard and soft mudstones, with strongly glaciated erratic boulders), and the boulder beds are separated from one another by thick deposits of sandstone and conglomerate.

At Wild Duck Creek, Derrinal, near Heathcote, there are similar Lower Silurian beds and Permo-Carboniferous glacial beds. There is good palæontological evidence that the erratic bearing mudstones of Maria Island and Bruni Island (both off the east coast of Tasmania), the similar beds at Maitland, Branxton, and Grasstree in New South Wales, and those of the Bowen River Coalfield in Queensland, are of the same age, as the genus Gangamopteris, is distributed abundantly throughout the formations at all these localities. The glacial beds at Hallett's Cove, near Adelaide, which overlie Pre-Cambrian, and underlie Miocene beds are probably of the same Permo-Carboniferous age. The Permo-Carboniferous glaciation of Australia and Tasmania was perhaps homotaxial with that of southern Africa and India. In South Africa, Mr. E. J. Dunn in 1872 discovered glacial conglomerates, the Dwyka conglomerates, at Weltevreden Farm, near the junction of the Vaal and Orange rivers, and he found a specimen of Gangamopteris in the Lower Karoo beds above the Dwyka conglomerates.

In India evidence of glacial action in Permo-Carboniferous time was first observed by Dr. W. T. Blandford. It has

*For figures of Gangamopteris and Glossopteris, see Medlicott and Blanford's Geology of India.

been observed in the Talchir group, the Salt Range group, the boulder beds at Bap in Western Rajputana, and the Panjah conglomerates of Kashmir.

In the Argentine Republic, all the peculiar Upper Palæozoic and Mesozoic floras of Australia, the Carboniferous flora with Lepidodendron and Rhacopteris, the Permo-Carboniferous with Glossopteris, and Gangamopteris, and the Lower Mesozoic with Thinnfeldia odontopteroides have been discovered, and some boulder beds have been found by Professor Derby in southern Brazil, which may possibly be evidence of Permo-Carboniferous glaciation.

Mr. Hobson drew attention to a paper by Mr. A. E. Seward, M.A., Lecturer on Botany in the University of Cambridge, entitled, "The Glossopteris Flora," published in *Science Progress*, New Series, Vol. I. (1897), p. 178-201, with a bibliography of 62 references, which deals with the flora of the Permo-Carboniferous beds in which traces of glaciation occur.

Specimens of glaciated quartzite and of the overlying conglomorate, held to be a glacial boulder bed of Palæozoic age, both from the Varanger Fiord in the extreme north of Norway, were exhibited by Professor Dawkins, having been presented to him by Mr. A. Strahan, F.G.S. (*Vide* Mr. A. Strahan's paper "On Glacial Phenomena of Palæozoic Age in the Varanger Fiord," read before the Geological Society of London, on January 20th, 1897.)

On the motion of Mr. Saint the thanks of the meeting were given to Mr. Hobson for his paper, and the President invited discussion.

Mr. Dickinson asked what is to be understood by the term "Permo-Carboniferous."

The PRESIDENT: The question, I think, which Mr. Hobson wished to bring before us was that evidence is accumulating of glacial periods at geological epochs much earlier than the one which we hear of and talk about so frequently, and which has left evidence of itself on our neighbouring shores and in the drift deposits which exist everywhere around us. This evidence with regard to Australia as well as India has been before the public for some years now, and its geological age is pretty well fixed as being at the close of the Carboniferous age—that is, so far as we know it. Mr. Hobson has expressed surprise that anyone should be sceptical on the question of there having been a glacial period other than the one we know of as being so geologically recent; but I think it is quite reasonable that there should be sceptics, for the evidence has been, I must say, until these later years, very small. But evidence has been accumulating, and it is now becoming so strong that I do not know any geologist, if he examines the facts fairly, but will say that there has been certainly glacial action at far off periods in the earth's history. But "glacial action" does not mean a glacial period—what we speak of as "the great ice age"—the only ice age that is thoroughly well fixed in geologists' minds. The question is, have there been similar periods at former stages in the earth's history? There is no reason why there may not have been. If you have mountains high enough, and wind and rains prevailing, and other necessary conditions, then you may have glacial action. It exists at the present day, of course, in Europe, Tasmania, in India, and elsewhere, but that does not establish what is known to geologists as a glacial period. There is therefore, I think, some ground for scepticism which our friend Mr. Hobson seems to have spoken rather strongly about. An interesting part of the paper is that relating to the Glossopteris flora—that is, the Carboniferous

flora—and Mr. Hobson mentioned that there has recently come to our knowledge the fact of a similar flora having been found in Argentina. It is rather curious that, in 1859, the late Mr. Plant, an old member of this society, had a brother who was engaged in Brazil as a Mining Engineer and Inspector, and this gentleman sent over some specimens of the Carboniferous flora of Brazil found at that time, which Mr. Plant showed at one of our meetings. But they had not undergone any examination and naming by any scientific specialist, so they were sent to London, to Mr. Carruthers. I believe this Society was promised, after these specimens were exhibited, that it should have full information with regard to them. Mr. Carruthers, however, published remarks upon them in the *Geological Magazine*. He named some of the fossils as Flemingites, afterwards recognised as a form of Lepidodendron, apparently resembling some of our European Carboniferous plants, whilst others, as the Glossopteris, were strange to the British flora. Mr. Carruthers, however, was sceptical about certain things. He did not believe that this South American fossil flora was of the same geological age as our English coal flora; in other words, that the Lepidodendra were not such as could be assigned any relationship whatever with the English species. But I do not know that it can be said to be so now. The curious fact, however, is that amongst those South American fossils there were Lepidodendra as well as Glossopteris, bringing together, as it were, in that region the two floras, one of which, Mr. Hobson says, is of a distinctly southern type. But these are points rather outside the matter which Mr. Hobson has made the principal feature of his paper, and perhaps not altogether permissible.

Mr. Hobson, replying upon the discussion, said: I do not claim for the paper any originality. As to the term Permo-Carboniferous, I rather agree with Mr. Dickinson that it is

not altogether a satisfactory one. It seems to not make up its mind whether it is Permian or Carboniferous, but I suppose the explanation is simply this. In this country, as is well-known, there is a great break between the Permian and the Carboniferous—there is an unconformability as a rule—and that being the case it is easy to mark off one from the other in this country. There is no reason, however, why there should not be other parts of the world where the sedimentation should go on—and I believe it has gone on continuously, right away from Carboniferous into Permian times. I believe it has occurred in the United States.

Mr. Holroyd: And in Russia.

Mr. Hobson: It is not easy to draw a hard and fast line. These beds which are as it were at the top of the Carboniferous, and bottom of the Permian, and which it would be illogical to separate by a hard and fast line, are therefore called Permo-Carboniferous. There is also another reason, as in some cases the fossil flora has not been sufficiently minutely examined, to enable it to be stated with precision whether the fossils are truly Permian or Carboniferous. With regard to the sceptism as to there having been a glacial period other than the one to which the term is generally applied, I would say that it is not very easy to give a definition of what is required to make a glacial period—a definition that shall strictly mark off a glacial period from the mere evidence of ice action, and I think in the particular case of these beds in Australia, India, and South America, the action was so wide-spread as to point probably to something comparable at any rate to the great ice age. How far it is comparable I could not say. If purely local I cannot see how it could be marked over such a wide area. When the ice acted there is no doubt there were enormously thick deposits formed by its action, as

shown by those thick beds in Australia. So whether you call it an ice period, or say that there was a great amount of ice, without calling it an ice period, is not a matter of vital importance. There very likely may have been other glacial periods in the British Islands. There has been said to be a Permian glacial period, and I am inclined to believe it from having seen large masses of rock embedded in the Permian, or what are now regarded as Permian deposits in Devonshire. There are large masses of porphyry embedded in the sandstone. I do not say they could not have been transported by floods, but I am inclined to think it may have been glacial action. Then it would have this effect, it would rather help to account for the poverty of the Permian fauna and flora in the British Isles more especially. At any rate I think we ought to have open minds to look for evidence of glacialisation in times before the Pleistocene.

Mr. Dickinson: I have not the slightest doubt as to the existence of groovings on rock surfaces; the only difference of opinion is as to how they were caused. It may not have been by ice; the appearance may have been produced by means not yet demonstrated. We know that the face of nearly every fault met with shows striation, and all who are acquainted with the Shropshire coalfield know that one part of that coalfield actually slid from the other part. We have there a sort of flat fault—not absolutely flat; there is a slight inclination—and there is evidence that it has some time slowly but surely slid off. It is called the Simon fault, and is one of the flattest faults we know of.

Mr. Sutcliffe: I have noticed the same thing in Ireland. It would be very easy to mistake it for striation, but not caused by ice. I have found the same thing, in various parts of the country, underneath the coal.

Mr. Dickinson: What I object to is the taking what is hypothetical and treating it as proved.

The President: Quite right; but we are not all willing to accept everything that has been put forward this afternoon as having been the effect of ice action. However, we are very much obliged to Mr. Hobson for having brought this very interesting subject before us.

This concluded the business of the meeting.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART VII. VOL. XXV. SESSION 1896-97.

A SPECIAL MEETING of the Members was held on Saturday evening, March 6th, 1897, at the Society's Rooms, Queen's Chambers, John Dalton Street.

The President: Mr. MARK STIRRUP, F.G.S., in the Chair.

The PRESIDENT, in his opening remarks, said that this was the second of the *Evening* meetings for which provision had been made, in pursuance of the policy announced at the commencement of the Session of giving opportunities, of taking part in the proceedings of the Society, to those members whose avocations precluded them from attendance at the ordinary monthly meetings.

The PRESIDENT also drew attention to the interesting character of the fossils, which were on the table, in illustration of the papers to be read.

FURTHER NOTES ON THE SEA-BEACH IN CARBONIFEROUS LIMESTONE, DERBYSHIRE.

By Messrs. J. BARNES, F.G.S., and W. F. HOLROYD, F.G.S.

Since reading our paper before the Society on December 18th, 1896, on the "Sea-beach found at Castleton, Derbyshire, in Carboniferous Limestone,"* we have made further examination of the rock *in situ* with a view to obtaining confirmation as to the lateral extension of this

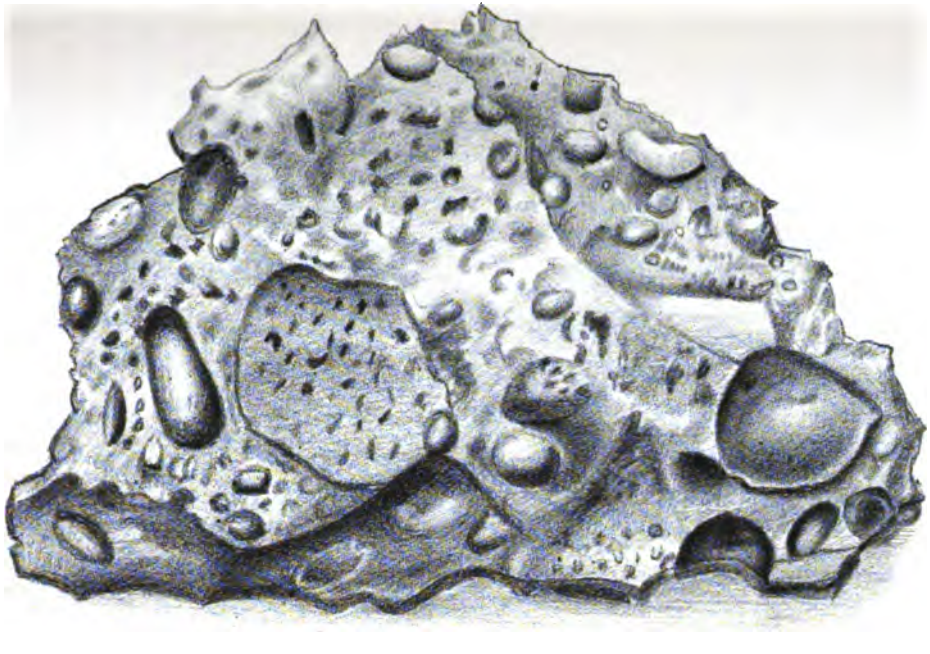
* *Man. Geol. Soc. Trans.*, Part IV., Vol. XXV.

beach, and with gratifying results. We wish to point out in this paper, the occurrence in the general mass of the limestone, of well-rolled fragments, of a very fine-grained limestone, of a different colour and texture to the general matrix, in which the pebbles are found embedded. These pebbles are quite distinct from the fragments of rolled shells mentioned and described in our previous paper, and make up a rock of puddingstone or conglomerate. Their shape points to the fact that they have been fragments of a previously solidified calcareous and coherent deposit, and that they are distinctly rolled and waterworn. They could only be waterworn by being rolled about in a shallow and disturbed water, caused by ebbing and flowing tides. The question arises: From whence have these pebbles been derived, and in what manner?

It would appear that there must have been some shore, or cliffs, or elevated land, capable of supplying this material.

The pebbles referred to are found most abundantly in the two districts of Sparrow Pits, and at a place half a mile west of Windy Knoll, near Castleton, Derbyshire. They are embedded firmly in the rock, and are scattered promiscuously throughout the mass, that is, not being specially arranged in layers.

They are of all shapes, mostly oblong, well-rounded, and as a rule somewhat flattened, varying in size from three inches in length, and two in width down to the smallest sized pebbles. Their texture is finer and of a darker limestone than that of the matrix. They are almost entirely composed of carbonate of lime, that is, they are limestone pebbles, and occur so far as we know in the uppermost beds of the limestone, not far below the Yoredale Rocks, and on the same horizon as that in which the fish teeth, and the rolled shell fragments described in our former paper are found. The pebbles do



Oolitic limestone conglomerate.

not appear to contain any visible fossils, but a microscopic section shows abundant foraminifera. The matrix in which the pebbles are found, is a well crystallized compact limestone, with abundant fine fragments of worn encrinital plates and stems, and occasional rolled fossil shells.

At a place half a mile west of Windy Knoll, we observed that some of the rock, in addition to containing the rolled shells and limestone pebbles, was distinctly oolitic, that is, contained numerous oolitic grains. These latter are of good size, up to one millimetre in diameter, and are easily recognised by their globular form, light colour, and concentric laminæ.

It is rare to find oolite in the Mountain Limestone, but it is found near Windy Knoll, and at Bristol. We do not know any previous record of it from the former locality.

Let us now consider the best means of accounting for the presence of these pebbles in this formation, in a little more detail.

It seems to us that the bed of the sea, or some part of it in this district, must have been elevated to some considerable height above the water, sufficient to allow the rock, which had hardened under the water previously, and which was laid down in deeper water, because of the fineness of the material, to become acted upon by the ordinary denuding agents. Portions of the rock would be broken off, and brought within reach of currents, or tidal water. After rolling about and rounding, these would be embedded in the sediment then forming at the bottom.

The pebbles have evidently been well rolled, and must have been subjected to considerable attrition to account for this. The disintegration of the rock would also supply the water of the sea with fine limy material sufficient to form the oolitic grains, with their respective coats or accretions.

We have in the specimens containing pebbles, a rock of two different ages and deposits, the pebbles being the older portion, and the matrix the newer one. So far as is known, the lower beds of the Carboniferous Limestone have never been seen in Derbyshire, and we know nothing of their colour and texture, but in other localities, the colour of the oldest beds are generally much darker than the uppermost beds of the Carboniferous Limestone.

From these facts, then, we may again come to the same conclusions as before, viz., that the deposits around the districts mentioned were made in a shallow sea, and with adjacent land areas, and we consider that this is very good evidence of the continuity of the shore line as we formerly described it, from Castleton to Sparrow Pits, a distance at least of about five miles.

ON THE OCCURRENCE OF LAMELLIBRANCHIATA, GASTEROPODA AND CEPHALOPODA IN THE MILLSTONE GRIT OF SOUTH YORKSHIRE.

By Messrs. J. Barnes, F.G.S., and W. F. Holroyd, F.G.S.

Following up our investigations upon the Yoredale Shales and Grits of Marsden Valley and Pule Hill, described in a previous paper,* we have examined the rocks above them, in the same locality, and of more recent age, *i.e.*, the Millstone Grit Shales and Sandstones, and now bring before you the results of our work. Comparatively little seems to be known to geologists of the fauna of the Millstone Grit. Even in Lancashire and South Yorkshire, where the beds attain their maximum thickness, there are only a very few places from which fossils have hitherto been obtained, other than plant remains.

Some of these places are Haslingden and Oldham in Lancashire, and Evesham, near Pateley Bridge, and a few

* *Man. Geol. Soc. Trans.*, Part V., Vol. XXIV.

other detached localities further afield, as Bristol, and round about Llangollen. It is very remarkable also to note the predominance of certain genera in some of these localities to the almost entire exclusion of others. The district from which the fossils on the table have come is in South Yorkshire, on the flanks of Pule Hill, known locally as Pule Side, at a small quarry called Netherley Quarry.

From the bottom of Marsden Valley to the top of Pule Hill, 1,440 feet above Ordnance Datum line, we have a regular succession of outcrops of all the beds from the middle of the Yoredale Shales to the Rough Rock, which caps Pule Hill. From the top downwards, the beds of the Millstone Grit, a sequence of fine-grained sandstones and shales, occupy 600 to 700 feet, below which are the Yoredale Shales. The second and third Grit series, which are the most important of the Millstone Grits, have great variety, and consist from the top of Pule Hill to the Yoredale Shales in the bottom of the valley, of sandstone, both pebbly and fine-grained, of thin flags, of freestone grits, *calliard* or bastard gannister rock, and seat earths, thin coal-seams, and shaly beds and bands. The shales, as is well-known, contain marine fossils, and the whole suite of beds contain plant-remains, but it is only in a few localities that geologists have been fortunate enough to discover marine forms, or estuarine forms of life-remains, in the gritstone, or fine sandstone. The beds in the quarry where the fossils are found, are those near the top of the Kinder Scout Grit, or in the bottom beds of the third Grit.

It does not appear to be capable of being accurately determined which of the two it is, as the beds of the Millstone Grit, almost more than that of any other formation, seem to vary locally, irregular lenticular patches of shales and coarse rock seem dove-tailed into the general mass, and thus causes much confusion. Almost the only points which

can be determined with certainty are the Rough Rock at the top, and the Kinder Scout Grit, at the bottom of the series.

The beds in the quarry at Netherley are worked for flagstones, which are about two feet square, and from one to three inches in thickness, and the fossiliferous bed from which the shells have been obtained, lies just above the flagstones.

It seems to be comparatively thin, only about a foot in thickness, and of a fine-grained texture, of the nature of a freestone, having few joints, and no micaceous partings.

The beds have a gentle dip to to the north-east of 12°. They are also about 200 feet above the Yoredale Shales, and 400 feet below the base of the Rough Rock.

The fossils consist mostly of casts, the shell substance in most cases being dissolved away, and often leaving only a mould of soft friable sandy matter to represent the fossils, which easily crumbles on being touched.

In other cases the lime is present and the casts and shells are better preserved. It has been found that excellent models of the shells can be obtained by means of suitable materials inserted into the cavities left in the rock, and these are often of great service in determining the species of the fossils. In such an openly porous rock as this sandstone is, we could hardly expect to find the fossils with their original limy covering intact, and only in very few of them is it so, but the cavities in which the shells lie embedded are very perfect.

It is convenient before describing the fossils found in the quarry at Netherley to see what has been found elsewhere with regard to the fauna of the Millstone Grit. In Geol. Mag., Vol. II., 1865, we have a paper on "the

Fig. 1.
Pleurotomaria conica.
PHILLIPS.

Fig. 2.
Pleurotomaria flamigera.
PHILLIPS.

Fig. 4.
Bellerophon hiulcus.

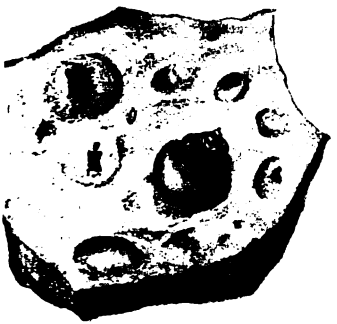


Fig 3.
Turbonilla.

Fig. 5.
Bellerophon Urii.

Fig. 6.
Naticopsis plicistria.

Fig. 7.
Buccinum imbricatum.

Fig. 8.
Loxonema Oweni.

Fig. 9.
Turritella.
———— P

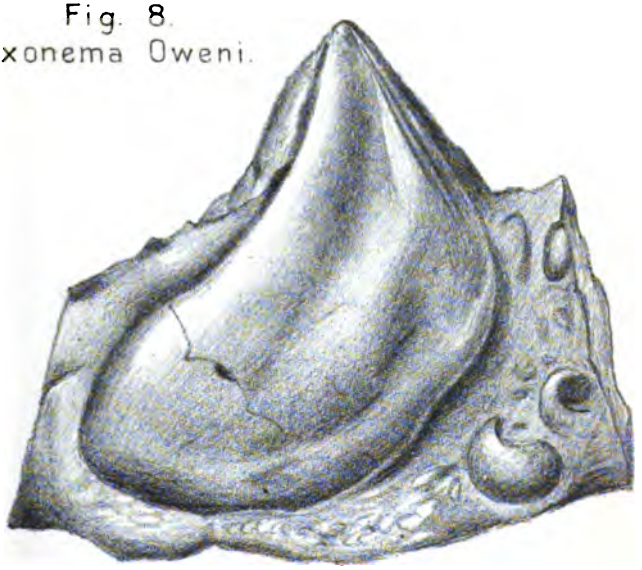


Fig. 10.
Myalina Verneuilli.
(INTERNAL CAST.)

Fig. 11.
Myalina Flemmingi.
(INTERNAL CAST.)

Fig. 12.
Schizodus Salteri.
(INTERNAL CAST.)

Fig. 13.
Machrocheilus imbricatus.

Fig. 14.
Sedgewickia attenuata.
(INTERNAL CAST.)

Fig. 15.
Rhizodopsis sauroides.
(FISH SCALE.)

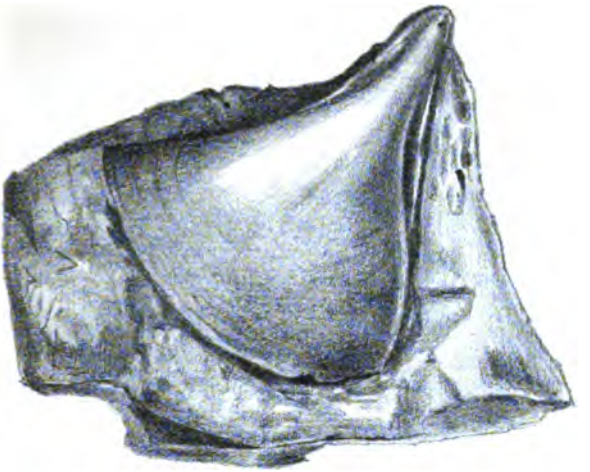


Fig. 16.
Myalina Verneuilli.
(INTERNAL CAST)

Fig. 17.
Pleurotomaria biserrata.

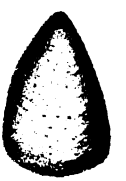


Fig. 18.
Posidoniella.
(INTERNAL CAST.)

Fig. 19
Goniatites.
_____?

Fig. 20.
Sandstone cast of Fish Tooth.

Fossiliferous Characters of Millstone Grit," by W. Prosser, F.G.S. We have fossils mentioned as coming from Sweeney Mountains, Vale of Llangollen, Trevor, Denbigh, &c. The grit here has only a thickness of 500 to 600ft., and the beds have been proved to be constant for over 20 miles along the margin of the North Wales Coalfield. Prosser says: The fossil remains found in the sandstone are in general but indifferently preserved. In the red sandstone they are often little more than casts, the calcareous matter of the shells having entirely disappeared, but in the cream coloured sandstones the shells are better preserved. The specimens recorded by him are: Pectens, Rhynconella pleurodon, Schizodus, Productus cora, P. concinna, P. semireticulatus, Orthis resupinata, Spirifera, Lingula mytilloides, Edmondia Sanguinolaria Pleurotomaria, Orthoceras, Trilobites, Phillipsia, and plant remains such as Sigillaria, &c. In Geol. Mag., Vol. VII., 1870, we have a paper on "Millstone Grit" of same locality, by D. C. Davies, of Oswestry. He enumerates the same fossils as above together with Metoptoma, Chonetes, Athyris, Nautilus, &c. Some of the Orthoceras found by him were 4 feet 6 inches in length.

In Geol. Mag., Vol. II., 1865, we have a paper on "Millstone Grit fossils and their relation to other rocks in the Bristol district," by Fort-Major Thomas Austin, F.G.S. He describes some 47 species as occurring in the Bristol area, of which one half are Brachiopoda (23 out of 47). 1 Gasteropod, 20 Conchifera, 2 Crustaceans, 1 Fish remains. The paper has been very sharply criticised however, and it is probable that not more than one half the number of species mentioned really exist, and most of those to which new names have been given are identical with specimens in Carboniferous Limestone below or Coal Measures above.

The following is the list of fossils hitherto found at Netherley by us, and it will be interesting to compare them with those mentioned by the authors previously quoted :—

Brachiopoda.

None.

Lamellibranchiata.

Myalina Verneuilli.
„ *Flemmingi.*
Sedgwickia attenuata.
Schizodus Salteri.
Posidoniella (—) ?

Gasteropoda.

Pleurotomaria conica.
„ *flamigera.*
Machrocheilus (—) ?
Rissoina (—) ?
Loxonema Oweni.
Bellerophon hiulcus.
„ *Urii.*
Naticopsis plicistria.
Turbonilla (—) ?
Buccinum imbricatum.
Turritella (—) ?

Cephalopoda.

Goniatites (—) ?

Fish remains.

Scales, teeth and spine.
Ctenacanthus tenuistriatus (spine).
Rhizodopsis sauroides.

The plant remains common in the quarry in the flaggy beds beneath the fossiliferous zone, are Lepidodendron Sternbergi, L. obovatum, Stigmaria ficoides, and Sigillaria reniformis. Abundant worm tracks, worm casts, worm borings, drainage marks, and ripple marks are found on the flags in the beds above and below the fossiliferous zone.

From the above list it will be seen that the Gasteropoda are predominant. The specimens of Bellerophon hiulcus and Urii occur in thousands.

The Lamellibranchs, Myalina, and Sedgwickia are also very abundant, and it is interesting to note that the Sedgwickia is only previously known from Ireland.

In the Bristol and North Wales areas it is always the Brachiopoda (Producti) which are the most common, and

the Gasteropoda so scarce that only one (a Bellerophon) is mentioned as occurring in these localities.

Geologists have generally considered the Millstone Grit devoid of fossil shells, a sort of sandy Lybian desert compared with the teeming life of the Coal Measures above, and the Mountain Limestone below. This is certainly not so in a few limited areas, and entirely not so in the district we are speaking of.

With regard to the origin of the matrix in which the fossils are found, we have a rock composed of fine grains of sand (quartz), probably derived from the decomposition and disintegration of Cambrian and Silurian rocks to the north and west.

The appearance of the beds, the flagstones, and the fossils, of the ripplemarks, water drainages, worm casts and worm borings, and tracks, seem to us to point to shallow water-deposits, more of an estuarine nature than marine, to sediment brought down by some large river, and deposited around its mouth, and yet at some dstance from the mouth, because we have no coarse grits, and to point also to warm submarine sandbanks, exposed at times to the air, and within tidal reach, capable of receiving fresh accumulations of fine sandy detritus, and of drifted vegetable remains, such as barks and stems of coal-forming plants. As to the question: Why should these fossils be so local? present in one place, absent in another, no decided answer can be given capable of entirely satisfying our enquiries. All that can be said is, that the conditions were more favourable for the life and preservation of these creatures. The physical conditions too, had much to do with the life of these organisms, that is, the shallowing and deepening of the waters, the deposition or otherwise of sediments, &c. Or it may be that a better food supply at a particular spot, warmer currents, sheltered banks, &c., may account for

their flourishing so abundantly, while the absence of these favourable conditions may have prevented their growth and development. Afterwards, during deposition of the upper beds, the conditions became unfavourable again, for the beds are devoid of marine or estuarine fossils.

Suggestions have been made recently from different sources that the time has come when the whole of the beds lying between the Coal Measures above, and the Mountain Limestone below, should be regarded and united by name into one great group, which varies according to local conditions, and which at one time and place is sandstone, at another, shale, and again in another limestone, with of course their corresponding suitable fossils. However this may be, we shall have to regard the waters in which the Millstone Grit were deposited, as being in places full of that life, the study of whose remains is so interesting to us all. The following names and brief descriptions refer to the figures:—

Pleurotomaria conica.
P. Squamula (Phillips).
Helix Carinata (Sowerby).

Fig. 1.—This Pleurotomaria resembles conica. It has an acute spire at an angle of 60°, is umbilicate, the band is bicarinate, with medium furrow, it has five to seven whorls, smooth interior, and bears traces externally of spiral striation. The figure is natural size.

Fig. 2.—Pleurotomaria flamingera. Phillips. Acute spire of five whorls. Surface decusated with spiral and longitudinal striæ, band broad, depressed, with acute striæ.

Fig. 3.—Turbonilla. Obtuse spire of about five to seven whorls. Angular above. Finely striated.

Fig. 4.—Bellerophon hiulcus. Subglobose, umbilicus small, rounded, dorsal band broad, striæ sharp, arched from

umbilicus to a deep V shaped dorsal sinus. The commonest fossil in the sandstone of the quarry at Netherley. Occurs in thousands.

Fig. 5.—Bellerophon Urii. Flemming. Globular. Aperture very expanded, axis solid, no band, smooth, many regular spiral furrows, intermediate ridges narrow, rounded, cast of interior smooth.

Fig. 6.—Naticopsis plicistria. This shell is a common one and well preserved.

Fig. 7.—Buccinum imbricatum. Sowerby. Ovato-lanceolate, whorls six, slightly convex, smooth, finely striated, striæ nearly direct.

Fig. 8.—Loxonema Oweni.

Fig. 9.—Turritella.

Fig. 10.—Myalina Verneuilli.

Fig. 11.—Myalina Flemmingi.

Fig. 12.—Schizodus Salteri.

Fig. 13.—Machrocheilus imbricatus

Fig. 14.—Sedgwickia attenuata.

Fig. 15.—Rhizopsis sauroides.

Fig. 16.—Myalina Verneuilli.

Fig. 17.—Pleurotomaria biserrata. Conical, acute, six to eight whorls. Sutural edge and lower angle of whorls carinate, three furrows, oblique striæ.

Fig. 18.—Posidoniella. Cuneate, oblong. Lines of growth, prominent. Surface, granular.

Fig. 19.—Section of Goniatites.

Fig. 20.—Tooth of fish.

On the motion of Mr. Ashworth, seconded by Mr Scowcroft, a hearty vote of thanks was given to Messrs. Barnes and Holroyd for their communication.

THE EFFECTS OF MARINE EROSION AS SHOWN BY THE SEA CLIFFS AND SEA CAVES OF THE BRITISH ISLES.

By Mr. Mark Stirrup, F.G.S.

The evening meeting was brought to a successful close by the exhibition, with the aid of the lantern, of a fine series of photographic slides of examples of coast cliffs and caves, illustrating the work of the sea.

The views embraced the Mountain Limestone caves near Tenby, and the cliff scenery in the neighbourhood of St. Govan's Head, Pembrokeshire, South Wales.

Some remarkable scenic views from the coasts of Clare and Mayo, in the West of Ireland, exemplified the action of the sea in the erosion of the coast and the formation of caves, islets, and detached rocks.

The rock-bound coasts of the Western Isles of Scotland and the mainland contributed many examples of the destructive power of the ocean waves, such as characteristic views of the isles of Staffa, Mull, and Skye, Cape Wrath, the Old Red Sandstone cliffs of Orkney, and the mural precipices of Caithness-shire, so dear to the memory of Hugh Miller.

The granite cliffs of Aberdeenshire and the Buchan coast were also brought into requisition, in order to show that even the hardest rocks yield to the continued and oft-repeated attacks of the sea waves.

Mr. Stirrup referred in his running commentary on the photographic slides to the variable power of resistance which rocks possess, to shock and weathering, according to their mineral composition and geological structure.

Attention was drawn to the influence of the direction of the bedding and jointing in the formation of isolated rock stacks and sea caves.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART VIII. VOL. XXV. SESSION 1896-97.

The ORDINARY MEETING of the Members was held on Tuesday, March 9th, 1897, at the Society's Rooms, Queen's Chambers, John Dalton Street.

The President, Mr. MARK STIRRUP, F.G.S., in the Chair.

FLOODING OF A COLLIERY SHAFT AT DOVER.

Mr. JOSEPH DICKINSON said: Before we proceed with the ordinary business I should like for a moment to bring under the notice of the Society the irruption of water which has taken place into the shafts which are being sunk to the coal at Dover. It is a sad sequel to the paper which was recently read before this Society. So far as I can make out from the detailed sections at the depth given, 300 feet, the water burst in just as they were about to reach the Greensand; and that, I believe, from the little experience I have had of it, is a very porous bed of soft sandstone. I recollect in Surrey where the Fuller's Earth (which overlies the Greensand but is not represented at Dover) was being worked at Nutfield, near Redhill, after some very wet weather the water found its way up from the porous rock into the Fuller's Earth Mines, causing serious damage. Great care has always to be exercised in sinking through the Greensand. It seems very similar to the bed of soft sandstone underlying

the Magnesian Limestone in the County of Durham, which has caused a great deal of both trouble and expense.

The PRESIDENT: Mr. Gerrard, H.M. Inspector of Mines, has the Dover sinking under his inspection, and we shall probably hear something from him, at a future meeting, about it.

INTERNATIONAL GEOLOGICAL CONGRESS AT ST. PETERSBURG.

The PRESIDENT called attention to the arrangements for the International Geological Congress to be held at St. Petersburg during the present year, and the special facilities that had been granted to geologists for visiting distant parts of the Russian Empire.

ON THE INCREASE OF FAN GAUGES IN MINE VENTILATION OF THE PRESENT DAY; WITH SOME NOTES ON VENTILATORS.

BY REV. G. M. CAPELL.

The "seventies" saw the rapid introduction of the mechanical ventilator in mines in this country, and the Chesterfield Institute fought the battle between the Guibal Enclosed Ventilator and the open running fans, not of English but of foreign design, slightly altered, in this country. Opinion remained divided, and the exhaustive report of the Northern Institutes on various ventilators, in 1878, such as the Guibal, the Waddle, the Schiele, the Struvé, the Nixon, the Goffin, and the Cook Ventilators, only confirmed the excellence of the Centrifugal Ventilators over all other systems, but did not add much to what was already known. The gauges of all the ventilators tested were also very low, the highest Guibal fan gauge being under 3½

inches, the highest Waddle gauge rather less. Little happened for some years to raise the fan question, until a sharp controversy arose in the *Engineer* concerning a new fan—the Capell—which, in 1883-1884, was the subject of great discussion, from some abnormal results observed in tests by Mr. D. K. Clark in England, and Mons. H. Rochet, Inspector General of Mines, in Paris. This fan, after much opposition, became a confirmed success at Waleswood Colliery, near Rotherham, where a 10 ft. fan gave, and is still giving 105,000 cubic feet at 3·25 inches water gauge with 210 revolutions, and the era of the high speed, high gauge fan, from that time began in earnest, though the Schiele fan, as a low gauge, high speed, ventilator had been extensively used in this country. In 1887 the Prussian Fire-damp Commission published its report on Mine Ventilators. It is the most exhaustive ever published. The fans experimented on were the Guibal, Kley, Schiele, Winter, Rittinger, Wagner, Zimmerman, Moritz, Pelzer, Fabry Positive Ventilator, and Root's Ventilators, and a Screw Ventilator, Kaselowski by name. Nearly 200 ventilators were tested; Mr. G. Herbst of the School of Mines, Bochum, being the engineer of the commission, and conducting tests. Looking over these results we find most of the highest gauges shown in actual work were by Guibal's fans, that at Gerhard Prinz Wilhelm, Albert-Schacht Colliery, 33 ft. 9 in. diameter by 10 feet wide, gave 94 millimeters or 3·45 inches. Next to this are high gauges shown by Twin Schiele fans, running at 562 revolutions and showing 4-05 inches water gauge, fans 5·3 diameter.

Another pair on Pluto Colliery at 420 revolutions gave 3·5ins. water gauge, but experience was wanting as to the higher gauges represented by 6 to 12 inches in large volume mine ventilators. The need of more air became keenly felt. The monstrous fans, Guibal, Giesler, and Kley, had reached their

limits as to speed, and still the cry was for more air. In November, 1888, Mr. G. Herbst experimented on a 3ft. Capell fan at the School of Mines, Bochum, and declared that the results he obtained were above any obtained by the Prussian Fire Damp Commission in their tests. This was accepted and the first Capell fan used in Germany showed with ease 5½ inches water gauge. It was an 8ft. fan and running at 325 turns per minute. At the end of 1889 several fans were giving 6 to 7 inches water gauge, and at that period the mine Prosper I., at Kray, Westphalia, having a 40ft. Guibal fan, required a volume of 123,000 cubic feet of air in place of the 70,000 cubic feet given by the Guibal fan. Careful experiments were made to establish the work of the Guibal fan, and the writer came to the conclusion, after experiments with the Capell fan, that the volume would be obtained with a drift gauge of 11 inches, or 325 revolutions, the fan being 12ft. 3in. × 6ft. double inlet, which is the most liked in Germany. The calculation from the Guibal inlet gauge showed a higher gauge than this, and in consequence a most stringent guarantee was demanded. The 12ft. 3in. fan was tested by Mr. G. Herbst, and the result came out :—Revolutions, 323,

Cubic feet, 127,300,

Water gauge, 10·7 inches,

the estimate having been 123,000 at 11 inches water gauge. Two very high gauge fans of the same type followed this at Wirkowitzer Colliery, in Austria. One giving 140,000 feet at 8·5 inches water gauge, the other reaching 14·7 inches with rather less air. These were 12ft. 3in. single inlet fans. At Grand Buisson Colliery, Belgium, another fan was erected showing 8 inches in regular work, and another at Saare et Longchamps, in the same country, giving the same water gauge. In France, at Crespin les Anzin, two fans (12ft.) were placed giving over 7 inches, and from that time fans giving 8 to 10 inches have been common.

A great stress has been laid on a high manometric efficiency in fans, *i.e.*, a low speed of periphery to produce the given gauge. In 1891, the fan of Professor Rateau was much spoken of as giving 90% monometric effect, but that was partly due to the fact that a conical adjutage with small end at the fan inlet was used, and in almost every case the gauge tube end was placed in this. Experience has shown that if the gauge tube is placed 80 or 90 feet away from the fan inlet, as in Mr. G. Herbst's experiments, a great reduction in gauge takes place, and furthermore, that in ordinary conditions of regular work, a very high manometric effect means a *low useful effect.* The writer, by experience with many fans at gauges from three inches to twelve inches, and exhausting from 60,000 to 240,000 cubic feet of air per minute, has come to the conclusion that a monometric effect of 55 to 60% by Monsieur Daniel Murgue's formula $h = \frac{v^2}{g}$, where v^2 = velocity of blade tip per second $g = 32{\cdot}2$, and h = height of air column due to velocity; gives the best useful effect. As long as the fan, built of Siemens-Martin steel, and stayed to meet the centrifugal strains, can run in *perfect safety*, a few turns more or less per minute makes no difference, and the gain is in useful effect.

The demand for high gauges is increasing. In England, on the Continent, in the United States, gauges are asked for now which were not thought of, even ten years ago. Why is this? As mines run out further from the shafts, as the workings are sunk deeper, the rubbing surfaces are constantly increasing, and the *leakage* appears to increase also, judging by figures submitted in recent years. To meet this the fan *gauge* must increase, or air ways must be *enlarged.* The Continental Engineers have had to face the difficulty in their thin seam mines, and rock-driven air ways, and have decided that a high gauge fan, with compound condensing engine, is the cheapest way to meet the difficulty, and now

boldly attack the problem on these lines. Of course, English mines, with their thicker seams, are far more favourably situated, but in the last two years gauges of four, five, six, nine, and twelve inches have been asked for in England, though the engine power required for large volumes at such gauges appears to retard the adoption of the high gauges in this country. One Capell fan, at work at Woodthorpe Colliery, Sheffield, has worked at over nine inches water gauge, and in regular work shows seven inches; this is probably the highest gauge in England.

A suggestion has been made for the dusty collieries of the United States, which is about to be put into effect, viz., to put the Capell high gauge fan on the mine, to work at four inches water guage passing a large volume of air, and to have power to run it to *ten inches*, when the air ways will be *swept clean* of dust, the men, of course, being out of the mine. There is no doubt about the practicability of such a course, as at these *high gauges* on an *ordinary* mine not requiring it, the air current is tremendous. It is sometimes thought that a high gauge *must mean* a high air velocity. This is not necessarily the case. Suppose a mine, the writer has one in his mind now, getting only 70,000 feet of air with a 36 feet Guibal fan, at 1·7 inches water gauge. To double that volume will require four times the water gauge, or 6·8 inches water gauge. The air volume will then be 140,000 cubic feet per minute, no unusual volume, and the air velocity in the roads will not be excessive. There are numbers of mines in about this condition, and the high gauge fan is specially adapted for them. Since writing this, a demand has come from a mine with a 36 feet Guibal fan, passing 60,000 feet at three inches water gauge. To meet the demand for double the volume, the Guibal fan would require twelve inches water gauge. The high gauge fans here referred to will give this volume on a Drift gauge of

nine inches, as proved by numerous applications on mines having large Guibal fans replaced with the small fans. These large fans appear to raise a local gauge near the fan inlets, and, as a rule, the Guibal fans have their gauge tubes placed in this position. The writer has made many experiments with a view of improving the high gauge fans, and in 1893-94 introduced the new *scoop fans, i.e.*, fans having scoops on the inner wings. The first patent dealing with this improvement had a scoop on the inner wings, which projected towards the edge of the inlet, dying away towards the centre. This had a great fault. It crowded the air to the ring which projected towards the fan drift, and, when at work, there was a large volume of air driven outwards, not entering the fan. It was evident the scoop thus formed was not satisfactory, though the fan gave fair results. The new fans of 1894 remedied this. The scoops had their greatest projections near the centre, the ends near the outer edges of the inlet were placed inside the fan and delivered the air between the wings. The first fans tested proved their great superiority over the former fans. The 12ft. 6in. fans at Allerton Main Colliery, giving 240,000 cubic feet per minute at 215 revolutions, with 4·3 water gauge, against 199,500 of the old Capell fan at Silverhill Colliery, of the Stanton Ironworks Company, at the same revolutions, with 4·1 inches water gauge; and the width of the fan was only ten feet, against eleven feet of the Silverhill fan. The fifteen feet single inlet fan at Hutton Henry Colliery, Wingate, showed 216,000 cubic feet per minute with 6·14 inches water gauge, against 149,200 cubic feet of the fifteen feet fan at Digby Colliery, near Ilkeston, with the same number of revolutions and six inches water gauge.

The scoop wings had added to the fans power of passing air, and improved the gauge though passing *larger volumes.*

In the United States several of these fans are at work on wide mines, giving extraordinary volumes of air. The 8ft. by 7ft. double inlet fan at Moon Run Colliery, Pennsylvania, giving 140,000 cubic feet at 1·7 inch. water gauge at 240 revolutions, the guaranteed speed of this fan is 320. At this speed the fan will give 186,660 cubic feet per minute, and the water gauge will be over 3 inches.

But another fan, 8ft. by 3ft. 6in. single inlet, at Youghiohenny River Company, Scott Haven, Pa., electric driven, far exceeds this, passing 85,000 cubic feet per minute at 208 revolutions, with 1·1 inch. water gauge. A second fan has recently been put down. The speed of these fans is 300 revolutions in the guarantee, and they can give 122,000 cubic feet per minute on a wide mine such as those on which they are working.

The useful effect measured by electric instruments is over 80 per cent.; electric driven fans giving a higher percentage than engine driving by belt.

The reason that mention is made of these fans is to show that the *scoop* fan is as effectual at low as at the high gauges.

Three high gauge large volume fans were last year started in Germany.

One at General Blumenthal Colliery, 13ft. 6in. by 6ft. wide, double inlet fan. This fan gave 227,000 cubic feet at 12·5in. water gauge.

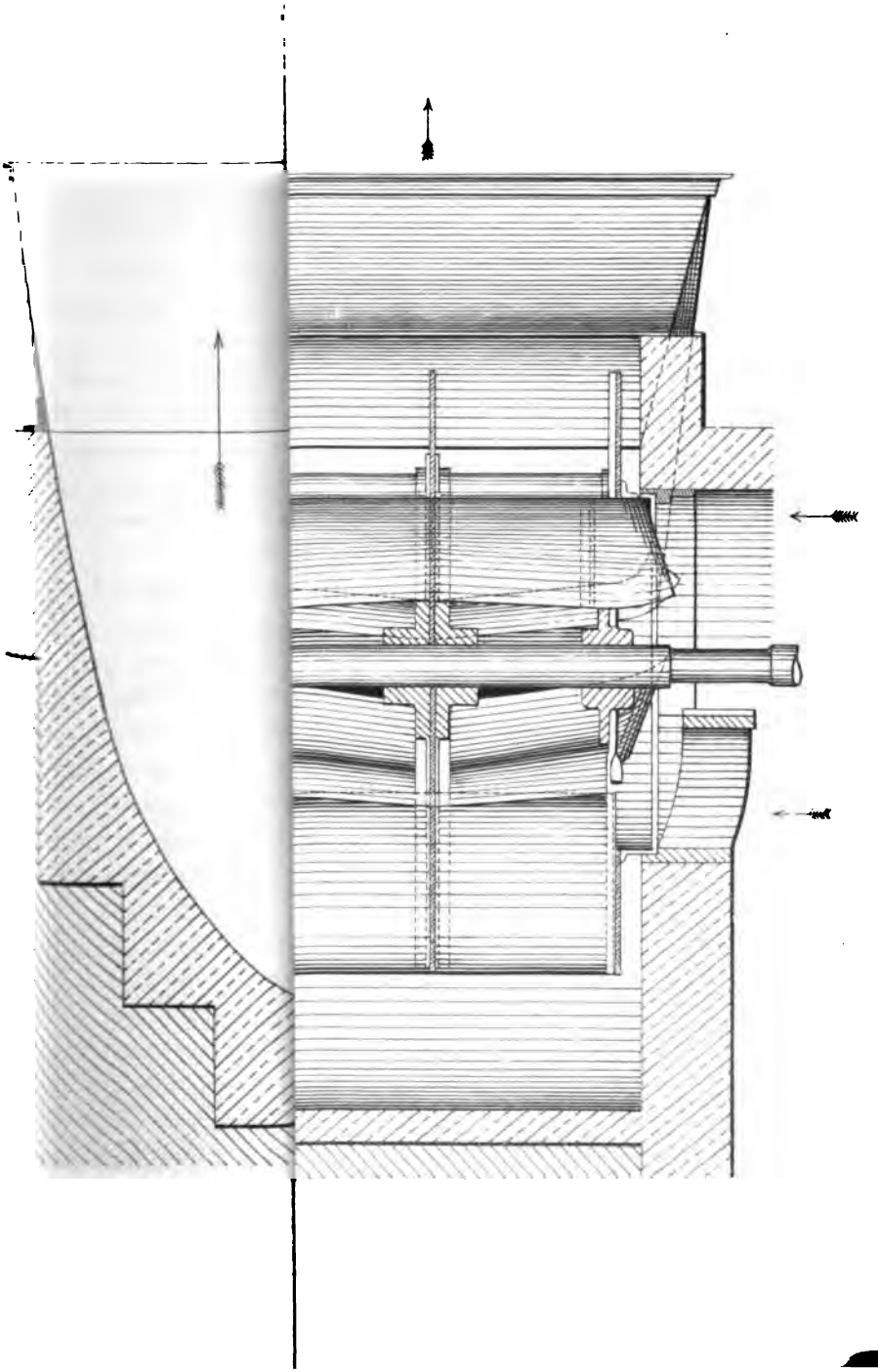
Another, the same size, at Pluto Colliery, gave 240,000 cubic feet per minute, at 11·25 inches water gauge.

The third, 13ft. by 5ft. 6ins., double inlet, at Prosper Colliery, gives 218,000 cubic feet, at 10·25 inches water gauge.

Several fans are now in construction to give from 180,000 to 225,000 cubic feet, at from 10 to 12 inches water gauge.

It is quite evident that the high gauge period of mine ventilation has come to stay. At this time it is only an

Trans. Min. Geol. Soc. Part VIII Vol. XXV
to illustrate Rev G. M'Capell's paper.



English fan which can give these large volumes and high gauges on the continent in regular and satisfactory work. No other fan has ever been able to guarantee either the volumes or the gauge.

In the United States these fans are being used as blowing and exhausting fans. Blowing down the mines in winter and exhausting in summer, and the results are equally satisfactory, and giving up to 200,000 cubic feet, and 6½ inches water gauge, at 208 revolutions.

When the writer first brought out the mine fan in Germany the scientific papers were rather severe on the presumption of a foreigner coming into the "home of the centrifugal fan" and trying to teach anything. The result has shown that *there was* some improvement to be made, and this is now cordially accepted in that country. It was thought better not to bring the improvements made prominently forward until the results were established by fans working under every possible condition of mine ventilation, which is now the case in England, in the United States, and on the continent of Europe.

It may be well to mention that the scoop inner wings are used with various forms of outer wings, set at angles suitable for the gauges at which the fans have to work,—a matter of some inconvenience to the manufacturers, but a gain to the users of the fans.

On the continent just now, the Rateau, the Mortier, and the Capell are the competing fans. The Rateau has certainly the highest gauge for a given periphery speed, but the writer has no knowledge of any working with over 100,000 cubic feet per minute, or gauges over 5 inches.

The Mortier is a new fan passing its air on the principle of the old paddle wheel fans much used on American mines, having no inlets and not working by centrifugal action. Mr. G. Herbst has made a study of this fan, and published

his investigations last year in *Gluck Auf*, the mining journal. He maintains that the gauge is not the same as in centrifugal fans, and cannot be used in the same way in the estimation of useful effects. On the Continent the rapid spread of fast running fans is quite remarkable. It is allied no doubt with the necessity for higher and increasing water gauges on the mines. But another point has also influenced the mining engineers. With a large fan direct driven 70 or 80 revolutions in regular work is a high speed. Suppose a fall of roof or some interruption in the air way, or a sudden outburst of gas, by speeding the engine up to 100 revolutions, only a comparatively small extra result is obtained. But with a high speed fan, with good engine of ample power running at 50 revolutions if that is run up to 75 to 88 revolutions an enormous increase of power to pass air is present and the engine is not overtaxed, and the fan perfectly able to do the work required.

In giving an account of the increase of high gauges, the writer feels that the matter is almost too personal, but he hopes that the part he has been obliged to play in this sphere of mine ventilation will be accepted as the excuse for having to speak so much of his own experience in a field, which in 1890 was unknown ground.

Mr. W. S. Barrett said: I have been asked to move a vote of thanks to Mr. Capell for his very interesting paper, and I do so with great pleasure. The last sentence he read showed the great progress which has been made, within a comparatively short period, in this system of ventilation. One remembers when furnace ventilation was almost the only system in use in Lancashire Collieries; and when we think to what perfection, in a comparatively short time, these fans have been brought it is a matter of great congratulation. This Society is very much indebted to

Mr. Capell for coming to give us the benefit of his experience and knowledge, and the results of his long and arduous labours.

Mr. Joseph Dickinson said: I have much pleasure in seconding this vote of thanks to Mr. Capell for his very instructive paper. It is on a subject to which, in the year 1860, the late Mr. John Job Atkinson and myself commenced making a very large number of experiments. We tested every form of ventilator then at work in North and South Wales, Belgium, France, Germany, and England; therefore I speak with some amount of confidence when I say that the paper we have heard to-day has been written by a practical man, and one who knows what he is writing about. He has given such particulars as will enable many members of this Society to study the subject for themselves. One cannot, from a rapidly read paper, lay hold of every point. The paper is one which will require study. I should like to mention that at the time of our experiments there was a large number of air pumps. The Struvé, then in common use, gave a very fluctuating water gauge. It oscillated from half a dozen inches down to nothing; and there was consequently great difficulty with the then water gauges in ascertaining what it was really producing. Until the compensating water gauges were introduced there was no means, except by buckets of water and a connecting tube, of ascertaining what the water gauge was. A description of those gauges will be found in Vol. XIV. of our Transactions. But there was another pump coming into use in those days, the Mahoux—a horizontal instead of a vertical pump—the invention of a Belgian engineer. That, like other pumps, was found not to utilise very much of the power expended in driving the pump. It soon gave way to the centrifugal fans, culminating for a time in the Guibal fan. This fan was the invention

of Monsieur Guibal, a practical and clever scientific man; he was then at the head of the School of Mines at Mons. The great points he laid stress upon were the means for utilising power—first, the shutter for contracting the air at the outlet from the fan; and secondly, the expanding chimney for allowing the air to pass out with the least friction. It would occupy too much time to go into any detail on the improvements of the Guibal, but I would like to mention, with regard to power utilised, that in no instance did we get anything like 80 per cent., as mentioned to-day by Mr. Capell. We got about 60. The pumps gave about 30, and some of the best centrifugal ventilators came up to 60; but none gave so much as 80. It was necessary to exercise great care with the water gauge. Very much depended upon the position where it was placed. I think the first person to call attention to the connection between the velocity and the pressure into an air way, or into a chimney, was a French writer, M. Péclet, who in his valuable work, "Traité de la Chaleur," showed that the pressure varied with the area and the velocity. Now, in Mr. Capell's paper, I did not hear any mention of velocity, and how to deal with the high amounts of air he has mentioned, in narrow airways. The best way of meeting the difficulty economically, he said, was by having a high water gauge. A high water gauge means a high velocity. To attain large quantities of air in very narrow air ways you would have such an inconvenient air current travelling that a man could not stand against it. Perhaps Mr. Capell will tell us what some of these velocities are, and what is a convenient velocity he would like to deal with. I know in some Continental mines, going back to 1860, the velocities were very high, the airways being small. The consequence was there were very high water gauges. I happened to mention one day to a Belgian colliery engineer that I would like to

see a large volume of air passing at a slower velocity and lower water gauge. He, I think to accommodate the visitors, set open the bearing doors between the shafts. It was a Sunday morning, and the men were not at work. Immediately the engine was started a current was produced which if it had not been stopped would very soon have broken the fan to pieces. The fan was that of M. Guibal.

The vote of thanks was passed unanimously.

Rev. G. M. Capell, in reply, said: I am exceedingly obliged to you, gentlemen, for this vote of thanks. It is a very great pleasure to me to read a paper before an appreciative and practical audience like this. With regard to the question raised by Mr. Dickinson about the velocity of the air, I think some remarks I made in the paper will be found to furnish an answer. The Continental mines are very much in the condition, now, of those one or two mines in England which I mentioned. For instance, we find a mine with a 40ft. Guibal fan passing 40,000 feet of air. Now, twenty years ago the quantity was nearer 120,000, but gradually the quantity has kept on diminishing as they go farther away and get into deeper seams. We find the high gauge fan then comes in, and passes the same quantity of air that was used originally to be passed by the mine—perhaps rather more. The result is the velocity of the air currents is not more excessive than it would be in a mine of good conditions, passing an ordinary volume of air. In some cases there has been a difficulty, mainly in the oiling of these fans. They found with ten and eleven inches water gauge it was not safe for a man to go near the fan inlet. Consequently, we put the bearings now clean outside the fan. We have very long shafts—16 inches, in some cases, in diameter in the centre, tapering off to each side, and the bearings are outside altogether. A much simpler way, to my mind, would have been to guard the inlets of the

fan by means of iron bars round the curve. The inlets could have been reached and oiled equally well; however, they approved of the other system, of having the bearings entirely outside. They have no inside bearings at all in the large fans, and some of them work at very high velocities. Down below, except just near the shaft and the main return—where there may be a very strong air current—there is throughout the workings nothing very particular, and I have never heard of any complaint on that score. I am very glad to say I have fans working in the most fiery mines in the world. The New Isolohn Colliery is well known throughout Germany. There they had three other fans in use—two large Guibal fans, which were connected with each other by telephone, and one of another type, the Pelzer—but they did not succeed in getting the required quantity of air; then they put in a Capell fan, giving 110,000 cubic feet at eight inches water gauge. I think, unless I read wrongly, we shall find, as the years go on, the same thing which is happening in Germany will take place in England, namely, more air per man and horse will be required in mines; and especially since the employment of high explosives so largely. In Germany they have had to use portable auxiliary fans, driven by compressed air, for driving away the fumes given off by the explosives. Now they have found that more air can be got by increasing the gauge, and there is a great demand for these high gauges which give more air under the existing conditions of the mine. Of course, the high gauge, in itself, is not a thing to be sought after; it is something that the mine puts upon our shoulders. If it cannot be met otherwise, we must overcome the difficulty with such mechanical appliances as are at our command.

ON THE PERMO-CARBONIFEROUS BOUNDARY.

By C. E. De Rance, Assoc.Inst.C.E., F.G.S., F.R.G.S., F.R.Met. Soc., H.M. Geological Survey of England and Wales.

In a paper "on the variation in thickness of the Coals and Measures of the Lancashire Coalfield," which I read before this Society on the 27th of March, 1877, just 20 years ago, I stated (p. 216) "from the presence of the Permian Rocks, on various portions, not only of the Coal Measure series, but of the underlying Millstone Grits, it is certain that these formations had already obtained their dip, and been subjected to lateral pressure, which squeezed and forced the older underlying strata up into a series of sharp anticlinal rolls, phenomena produced by the movement of subsidence taking place on the close of the Carboniferous period, which subsidence was followed by much contemporaneous marine denudation, which wore the surface of the various Carboniferous series, into a plain of marine denudation, on which was afterward deposited the Permian Rocks."

The first separate reference to the "Upper Coal Measures" in England appears in Elias Hall's key to the Geological map of Lancashire and Cheshire, where he originated the term "Manchester Coalfield," for these highest measures, which was adopted by Mr. Binney, in a paper read in 1839, and appearing in Vol. I. of the Transactions of this Society, he correctly regarded the Limestone of Ardwick and Whiston as the upper boundary of the field, and pointed out that the "Lower New Red Sandstone" of his day (subsequently "Permian") was unconformable. The correctness of this view has been subsequently borne out by the much described Levenshulme railway cutting and the numerous borings that have been made in the area around Manchester, Stockport, Bedford Leigh, and Newton-le-Willows,

the results of which have been published in the Transactions of this Society, and in the 22nd Annual Reports of the Underground Water Committee of the British Association.

Those who carefully studied the Levenshulme section, in sunshine and in shower, will remember, that in spite of much that has been written to the contrary, their respect for the colour-test of geological age was increased, the three formations, Upper Coal Measures, Permian Zechstein and Triassic Pebble Beds, each being characterised by distinctive tints, the Coal Measures were purple and showed every delicate shade of pink and green, of the colours, which are now known as "æsthetic," resembling those sometimes seen in the sky, during seaside sunsets, and also those curious decomposition colours, which occasionally painfully attract the artist, to the dissecting rooms of the Schools of Anatomy. These colours were early remarked by Mr. Binney, who probably correctly attributed them to the inpouring of volcanic ashes; the Permians, on the contrary, have a uniform staring scarlet, with crimson marls and occasional white bands, while the Pebble Beds range between brick-red and an almost orange tint.

The Levenshulme Limestones attain a united thickness of about 20 feet, the maximum record in one sequence in England. The earliest reference to limestones on this horizon was made by Sir Roderick Murchison, who, comparing Shropshire and Lancashire, stated: In the (Silurian System, p. 83) Shrewsbury Coalfield:—"The limestone at Pontesbury is about seven feet thick and is divided into two beds, the uppermost of which is a compact cream-coloured rock, slightly argillaceous, with a splintery conchoidal fracture and dull lustre. The lower, though essentially the same limestone, is cellular, the cavities being filled with crystallized carbonate of lime and black bitumen; both viscous and compact veins of carbonate of lime and

black bitumen are also disseminated through it." The following analysis is given of the limestone found at Bretchall, in the Shrewsbury Coalfield :—

Carbonate of lime..	93·7
Silica, oxide of iron and manganese	3·7
Alkaline silicate	2·6
	100·0

And of the Ardwick Limestone (p. 87, Silurian System):

Carbonate of lime..	84·0
Do. magnesia	2·0
Alumina	4·0
Oxide of iron	5·0
Loss	5·0
	100·0

Sir Roderick Murchison, in "Siluria," after describing the admixture of marine and fresh water forms in the Middle Coal Measures of central England, states :—" Other probable examples of such associations indicating the contiguity of land on which plants grew, and from which they were transported during long periods into estuaries, are seen near Shrewsbury, and other localities, among some of the younger coal strata, which in Manchester one sees to be of very great thickness." He describes the occurrence of *Spirorbis*, in the uppermost limestone of the Coal Measures in the two localities, and considers it a marine and estuary genus, associated with forms that may be marine as *Anthracomya* at Ardwick and *Leperditia* (Cytherea) *inflata* that may be marine.

Sir Charles Lyell commenting on these discoveries, considers the deposit probably took place in brackish water, but states that the cellular Limestones of Shrewsbury resemble some of lacustrine origin in Germany and France.

In 1840, a year later, Sir Joseph Prestwich, F.R.S., made an elaborate Report with map and sections of the Coalbrook Dale Coalfield, and showed that the higher seams of coal of the Middle Coal Measures, present in the northern end of the coalfield, were absent in the central and southern portions, and that the middle seams also die away southwards. The subsequent observations of the late Mr. Marcus Scott * and Mr. Daniel Jones † have shown that the attenuation is entirely due to very extensive denudation of the Middle Coal Measures, commencing after the "Chance Pennystone Seam" was formed, and that in the denuded hollow space the Upper Coal Measures were deposited against a sloping bank of the older Measures, the present base of the Upper Coal Measures being a bed of gravel and a mottled clay, locally known as "Calaminker." At the southern end of the field, the post "Chance Pennystone" denudation is so extreme that only 170 feet of measures are left between the *Spirorbis* limestone and the base of the Coal Measures, in place of 1,000 feet at the northern end, while in the southern area, as far as the Abberley Hills, the Upper Measures reach a thickness of 1,100 feet, as shown by the sinking at Shatterford.

In Lancashire, at Whiston, occur Upper Coal Measures, red and greenish mottled clays, with a two-feet limestone, resembling that of Ardwick, dip westward at 24 degrees, diminishing westwards to 5°, where they are overlaid by the Trias, the Permians being absent, unless they are represented by an intervening bed of soft red marl three to four inches thick.

Mr. Binney, writing in 1853, stated: "I am convinced that some of the mottled clays and shales of the Upper Coal Measures, as well as many of the Permian beds, have a great deal of volcanic ash in their composition.‡

* *Q.J.G.S.*, Vol. XVII., p. 457, 1861.
† *Geol. Mag.*, Vol. VIII., p. 200, 1871.
‡ *Man. Lit. Phil. Soc.*, Second Series, Vol. XII., p. 266.

In December, 1870,* Mr. Daniel Jones, F.G.S., gave a detailed description of the *Spirorbis* Limestone, in the Forest of Wyre Coalfield, lying between the Abberley Hills, in Worcestershire and Bridgeworth. The limestone had been previously described by Sir Roderick Murchison as occurring as far south as Tasley, over a range of 20 miles. Mr. Jones identified it at Harpesford Colliery, two miles south-west of Tasley, the section being:—

	Ft.	In.
Measures	32	0
Spirorbis Limestone (breccia) ..	3	0
Measures	63	0
COAL and thin partings	4	2
Measures	6	0

Southward it occurs, but was not recognised by previous observers, and was known in Pit Sections as: "Peldon," "Hard-white rock," "Light rock," and "Dunstone."

The limestone was thickest at Pontesford, in the Shrewsbury Coalfield; the following is the section:—

	Ft.	In.
Measures	90	0
HALF YARD COAL...	1	6
Measures	57	0
Limestone in two beds	7	0
Measures	33	0
COAL SMUT	3	0
Measures	6	0
YARD COAL	3	0
Measures	54	0
COAL	1	4

The rocks, now known as Permian, were first studied in Germany, and have been thoroughly investigated by the two Credners, Quenstedt, von Hauer, Gümbel, Ziltel,

* *Trans. Man. Geol. Soc.*, Vol. X., p. 37.

Geinitz, and many others; to Geinitz we owe most as regards Permian Palæontology generally, and to Credner, perhaps, most as to our knowledge of physical conditions and comparisons, whose generalized table is here reproduced, as regards the German sequence.

5. Deep Sea ..	Marine formations.	Limestone ..	Marine animal remains	*Zechstein;*	Dyas.
4. Subsidence under the sea.	Shore formations...	Conglomerates and Sandstones.	.....	*Rothliegende;*	
GENERAL UNCONFORMITY ("HÄUFIGE DISCORDANZ").					
3. Stationary broken by slight oscillations.	Fresh water and marsh formations broken by shore and shallow sea formations.	Coal-bearing strata.	Land plants.	*Coal-bearing Rothliegendes & productive coal measures.*	Carboniferous.
2. Elevation above the sea.	Shore formations..	Conglomerates and Sandstones.	.....	*Sandstones without coal seams; Culm; Carboniferous.*	
1. Deep Sea ..	Marine formations.	Limestone ..	Marine animal remains	*Limestone.*	

From this table it will be seen that the German geologists separate the coal-bearing Lower Rothliegende, from the Permians above, and the true carboniferous below. On this point the Rev. A. Irving, D.Sc., in 1882, called attention to the far greater simplicity of grouping these beds with the Carboniferous.

The German sequence is as follows, the Limestone disappearing southwards :—

Upper Zechstein :—

c. Plattendolomit, including fetid limestone (*Stinkstein*).

Middle Zechstein.—

b. Magnesian Limestone, *Rauch-wacke,* or Rauhkalk.

Lower Zechstein.—

a. { Grey earthy limestone.
Kupferschiefer, or copper bearing shales, with 47 amphibians in Bohemia.
Weissliegende, or *Grauliegende*, white or grey beds.

b. Rothliegende, or Todtliegende, at Eisenach, 4,000 ft.; in Bavaria, 7,000 ft.

a. Brandschiefer.—Bituminous shales with many ganoid fish.

In the above section, the reptile, *Prætorosaurus Speneri*, Meyer, occurs in the copper slate of Germany and Saxony, two species of this genus occur in the marl slate of Durham. The Palæozoic aspect of this life is most marked.

It is worthy of note that some French Geologists refer the upper and less productive Coal Measures of Central France to an uppermost or third member of the Coal Measures, others, to the base of the Permian.

This points to a true German Rothliegende overlaid by the Zechstein, with an unconformity at its base, and similar strata below it, with these coals of doubtful age; that this is in agreement with the English sequence will hereafter appear.

Murchison and Morris, writing of the district around the Wartburg, at Eisenach, and the Thüringerwald district, state: "The movements by which the great brecciated masses were aggregated were clearly suspended and repeated many times; the intervals of quiescence, allowing of those deposits, of finely triturated red sand and marl, which alternates with the coarse and subangular conglomerates. These breccias and conglomerates, with their associated sandstones, are of gigantic dimensions, and have been bored into in fruitless searches after coal to a depth of above 2,500 feet."

From this two-fold arrangement, these rocks in Germany are called "Dyas"; but proceeding southwards, the phrase

is no longer applicable, the Zechstein disappearing gradually, until in Bohemia it is absent, though fossiliferous fish bands of limestone occur. S.W. of Hunsrück, the base of the Rothliegende contains thin coals, and overlies productive Coal Measures. Lyell pointed out ("Students' Elements," p. 381,) that the German Rothliegende plants have a close carboniferous affinity.

In Thuringia the investigations of Prof. Geinitz have proved that the Middle and Lower Zechstein, including the "Kupferschiefer," of some writers, and the underlying Grauliegende (= Weissliegende) of marine origin, is the equivalent in time in adjacent parts of Thuringia of the Littoral Upper Rothliegende, and that both alike are overlaid by the Upper Zechstein with *Schizodus Schlotheimi*, and both alike are deposited on the Littoral Lower Rothliegende, consisting of well stratified brecciated sandstones and marls. Above this the Zechstein is extremely eroded, and on the denuded edge rests the lowest Trias, the "Bunter schiefer."

The Upper Zechstein, or Platten-dolomit of Central Germany, is (as pointed out by Geinitz) the equivalent of the Magnesian Limestone with *Schizodus Schlotheimi* of Lancashire, over which occurs the same break, with the lowest Lancashire Bunter above it. This denudation in Germany is extensive; it is not only water-worn, as in England, but has suffered subaërial action.

In the Eisenach district of Thuringia the Bunter consist of mottled sandstone, like the English lower mottled sandstone, overlaid by pebbly red sandstone, corresponding to the Pebble Beds. The Bunter overlap all members of the Permian series, and eventually rest on the Silurian Schists.

The "Dyas" arrangement does not appear to be well marked in Russia, where these pre-Triassic rocks, from their prominence in the Government of Perm—the old kingdom of Permia—were named by Sir Roderick Murchison, De

Verneuil, and Keyserling—PERMIAN:—they extend over an area larger than France, from the Volga to the Arctic Sea northwards, and east to the Oural; for though fossiliferous limestones occur mostly at the top, they alternate with sandstones and marls, and these last are associated with thin coals at the base, and with gypsum and rock salt at the top; beneath occur Coal Measures, but the seams are unimportant.

The Zechstein contains many plants, and a marine fauna, with *Productus horridus, Camarophoria Schlotheimi;* in it occur the great deposits of malachite, azurite, and other copper ores of the Ourals.

Reviewing the Continental facts, it would appear that the phrase "Dyas" is not applicable to Russia, or to parts of South Germany and Bohemia; consequently, the name *Permian* of Murchison is a convenient one, and is distinctly applicable to pre-Triassic rocks overlying the Yorkshire, Nottinghamshire, Lancashire, and Cheshire Coalfields, north of a line drawn from Birkenhead to Nottingham. It is possible that these Zechstein Permians extend a short distance southwards; but in any case, there is little reason to doubt that they terminate against a pre-carboniferous ridge, as originally suggested by my colleague, Dr. Hull, F.R.S., in which he pointed out that "the Permians" north of the ridge are of a wholly different type to those south of it, and were deposited in a separate basin and under different conditions.

As regards the Southern type, the question arises are deposits in the West Midlands, intervening between the undoubted Coal Measures and the Trias, all of one age? May the rough Conglomerates and breccias of Worcestershire around the Lickey and Clent Hills be *Rothliegende Permian,* and the Red Sandstones and Marls of Warwickshire be of older date and be *really* an uppermost member of the Coal Measures; or are the whole of the deposits south of the pre-carboniferous ridge referable to the Carboniferous system?

The Geological Survey of the Nottingham Country was made by my friend, Mr. W. Talbot Aveline, in 1859, and the Explanation of the map (71 W.E.) was published in 1861, he recognised the great break between the Permians and New Red Sandstone, but unfortunately did not state, in the wish to compress in the limits of a sixpenny pamphlet, the necessary facts, but in the *Geological Magazine* for 1877, p. 155, he states the Permians north of Worksop consist of:

4. Upper Marls.
3. Upper Limestone, with little Magnesia.
2. Middle Marls and Sandstones.
1. Lower thick Magnesian Limestone.

He shows that proceeding southward, the Trias gradually overlaps all the above in succession, and eventually rests on the Coal Measures. Therefore nothing can be more absolutely certain that, in this area, the Trias is unconformable to the various members of the Permian, and the latter unconformable to the Coal Measures beneath. In connection with the Nottingham Water Supply, I have this year carefully examined the whole of this area, and find the Keuper Basement beds, and the Upper Mottled Sandstone to be both absent.

The Rev. Dr. Irving, in the *Geological Magazine*, 1882, appears to have been the first to have shown, on chemical grounds, that the theory of *stained* carboniferous strata involves many difficult problems, and he is of opinion that the colouration "of the two* great Red series are (for the most part) *contemporaneous with their deposition*, and furnishes strong evidence of the 'Continental' conditions under which that took place."

Post-Carboniferous Red Rocks.

In reference to the colour test, some British geologists seem to place much importance, considering because certain tints occur in common in the Permian and Trias

* Referring to the Old Red and New Red Sandstones.—C.E.R.

Formation they form a united "Poikilitic," but every year's investigations show the absolute uselessness of this colour test, and that nowhere does the deep iron-tinged dyes exist in greater purity than in the Upper Coal Measures of Lancashire and Staffordshire, in reference to the horizon of which there is no question of dispute. The Palæontological division is equally marked; as Dr. Irving has pointed out that in Germany no genus of plants of importance is common to the Dyas and Trias; and of the *fauna*, only three genera of Brachiopoda, two of Lamellibranchiates, two of Gasteropods, and one of Cephalopods, are common to both groups.

In 1835, the red rocks overlying the Coal Measures were divided by Murchison (P.G.S., Vol. III.) into:—

1.	*Keuper*	Red and Green Marls.
2.	*Bunter*	Sandstones and Conglomerates.
3.	*Zechstein*..	Calcareous Conglomerates.
	Roth-todt-liegende..	Lower Red Sandstone.

Two years later, the Rev. Dr. Buckland compared the reptilian-bearing sandstones of Warwick to the Keuper building stones of Stuttgard and Sinzheim, near Heidelberg. It may be observed that the Warwickshire sandstones are interstratified with marl bands, locally called "way boards," dividing the beds into water-tight compartments and forming the typical "water-stones."

Mr. Binney, in 1842, in a paper given before the British Association, gave the following outline of the classification of the Lancashire and Cheshire post-carboniferous red rocks:—

		Feet.
1. TRIAS (Murchison)	*a.* Red and Variegated Marls	?
	b. Gypsum and saliferous marls	800
	c. Water-stones	440
2.	Bunter series	600
3. PERMIAN	Red and variegated marls, and Magnesian Limestone	210
	Lower New Red Sandstone .. .. :	120

It will be noted that in this classification the base of the Keuper was taken above the Lower Keuper Sandstone, Grit, and Conglomerates of Lancashire and Cheshire, which is represented in Warwickshire by a band only a few inches thick. It is important to point out that on the older Geological Survey maps of the former area, the base of the Keuper Water-stones f_5, is taken at the top of the Upper Mottled Bunter f_3, but in later maps of re-surveyed areas the soft current-bedded Frodsham Beds above, and the hard current-bedded Lower Keuper Sandstone, which in Lancashire and Cheshire intervene between the Water-stones and the Upper Mottled Sandstones, but which are absent in Warwickshire, or only represented by a band a few inches thick, have been separately mapped, and are indexed as f_4.

The break at the base of f_4 has been regarded as an important unconformity between the Keuper and the Bunter, representing, in geological time, the interval in which the Muschelkalk was deposited on the Continent. It is important to observe that if, for the purposes of physical study, the whole of the strata lying between the top of the Mountain Limestone and the base of the Keuper Waterstones be studied, irrespective of any previously conceived ideas, it will be noted that the sandstones at all horizons are all similarly *current-bedded*, all equally subject to extensive contemporaneous erosion; that physical breaks between members of the Zechstein Permian series are as acute as between the Permian and the Bunter series, or as between the Bunter and the Keuper, so far as regards its lower division, f_4, of the Geological Survey; and that the whole of the sandstones lying between the top of the Mountain Limestone and the base of the Waterstones have experienced recurrent conditions of erosion.

Warwickshire.—Mr. H. H. Howell describes (Exp. H. S. Sheet, 50-51, 1859,) the Permian beds lying between

Meriden and Bedworth as belonging to the horizon of those underlying the Clent Hills conglomerates, consisting of red and brown sandstone and calcareous conglomerates, with lenticular beds of red marl interstratified; and in the higher part of this strata the marl beds become more numerous and of greater thickness than the lower part of this series.

He describes the occurrence of silicified stems of trees and several species of *Caulerpites* and *Brera* at Allesley and Merinden, and *Calamites Mougeoti*, *Lepidodendron*, and casts of shells allied to *Stropholosia** from a sandstone at Exhall, and the remains of *Dasyceps* (*Labyrinthodont*) *Bucklandi* at Kenilworth.

Above the middle of the series, which he estimates at 1,500 feet, is the Corley conglomerates made up chiefly of Mountain Limestone pebbles. Below the Permians occur 150 feet of Upper Coal Measures, then the *Spirorbis* limestone from two to three feet in thickness dipping S.W. at 12°, below it occurs a further thickness of 530 feet of measures to the workable coals.

Denbighshire.—The late Mr. D. C. Davies, F.G.S.,† gave the following sequence of the beds below the Trias, in the S.E. corner of Denbighshire and the N.W. corner of Shropshire:

Dark red thick bedded sandstones with their beds of marls as base, with, locally, bands of small pebbles. At Whittington boring, two miles N.E. of Oswestry, and six miles south of the section in the Dee, below the Trias occurred 620 feet of fine-grained dark red and brown sandstone, occasionally streaked with white, and a bed of white sandstone two feet thick occurred at the base, resting on marls occurring on the base of his Group III. His identification of the beds was as follows:—

LOWER NEW RED SANDSTONES. GROUP IV.:—Brown grey sandstones, with gypsum, current bedded, resting

* *Q. J. G. S.*, Vol. XI., p. 198. † *Q. J. G. S.*, Vol. XXXIII., p. 10.

and overlapping over the lower strata at Croeswylan, two miles south of Whittington boring, they bore them from 620 to 700 feet, but here also they rest upon red marls. At Llynclys, two miles south of Croeswylan, they rest on the Carboniferous Limestone. At Alberbury, seven miles S.E. of Llanclys, they rest on the celebrated calcareous conglomerates.

GROUP III:—Measures			Unknown.
A	Double Coal or New Flannog	Coal ..	1 ft. 6 in.
		Fire Clay	10 ft. 0 in.
		Coal ..	1 ft. 6 in.
	Red and blue binds		210
B	Coedyrallt Rock, buff sandstone, with *Cornstones*		40 to 80 ft.
C	MORLAS MAIN COAL	4 ft. 9 in.	60 (?)
	Measures, plants, *nodules*		
	MORLAS LITTLE COAL ..	1 ft. 4 in.	
	Fire clay	4 ft. 0 in.	
	Blue slate		
D	Red, white, yellow, and brown marls, with green calcareous rock in middle, with thin bands of rock.		270

GROUP II. *Unconformity*—Grey and green rocks with brown and grey sand and gritstones, with pebbly conglomerated and brecciated beds lying in oval, wedge-shaped masses, in the midst of fine-grained sandstones and marls. The included pebbles and fragments consist of Cambro-Silurian rocks, associated with quartz, felspar, granite, and porphyry, together with Wenlock Shale and Carboniferous Limestone, all of which might have been derived from Glynceirog and Llanarmon; ten to twenty miles west drifted plant remains occur. In the west these beds are absent, or eroded, at Brykinallt Colliery, but are freely

present at Hafod-y-bwch shafts of the Ruabon Colliery, five miles to the north. Mr. Davies estimates this subdivision at 300 feet, and considered it the first of the Permians, an *unconformity* occurring beneath it in places.

GROUP I :—Grits, with thin coal seams and fireclays Green and brown sandstones. . . . . . Shale. . . . . . Rough rocks . . . . . . SPIRORBIS limestone	220 ft.

Leicestershire.—Mr. H. T. Brown, F.G.S., in his paper on the Permian rocks of the Leicestershire coalfield, has conclusively proved that they are the thin marginal representatives of the more ancient deposits of the Permian age in Warwickshire, and that the break is much greater in Leicestershire between the ordinary Coal Measures and the beds above, owing to the district being on the Pennine Chain axis, the Leicestershire rocks thinning out eastward and north-eastward against an old land barrier, as pointed out by Mr. E. Wilson, F.G.S. (Midland Naturalist, Vol. IV., p. 97, *et seq.*), and looking to the fact that Permians of the Leicestershire type are last seen at Ingleby, 13 miles from the Nottingham Zechstein, and that north the last is absent, as proved by coal trials at Wilford, Clifton, Highfield, Chitwell, and Owthorp, it is obvious that the conditions on the two sides of the barrier were entirely different, and the barrier was doubtless continuous with separating the Lancashire and North Cheshire Permians from the north-eastern counties. The Leicestershire quasi-Permians are unconformable to the productive Coal Measures which have been continuously denuded down to a point below the East Warwickshire, Spirorbis limestone, and I agree with Messrs. J. H. Teall, E. Wilson, and H. J. Brown, that the Pennine Chain was uplifted before Permian rocks of any type were deposited.

South Staffordshire.—Mr. Crosbee Cantrill, B.Sc., has, in a very valuable paper "on *Spirorbis* Limestone, &c., in the Permian rocks of Wyre Forest,"* pointed out that in South Staffordshire Jukes regarded the whole of the beds below the Bunter up to the boundary faults of the coalfield as Permian, and that further south they overlie the olive brown and yellow Halesowen Sandstone of the Coal Measures, rising to form the Wychbury, Clent, and Rowsley Hills. In the Clent district he points out that below the trappoid breccia and calcareous conglomerate with sandstone and marls is an older group of sandstone and marls, with badly preserved plant remains at Hasburg, near Halesowen, and that below all these beds, which are uniformly deep red or purplish, suddenly comes the yellow sandstones of Halesowen, 50 feet below the summit of which occurs a *Spirorbis* band.

He shows that even in Jukes's time a boring of 700 feet on Bullock's Farm had already proved a 10 inch coal, with fireclay and white binds,† in the midst of red beds, 511½ feet of red sandstone occurring beneath it. It is worthy of note that Dr. Hull, in 1869, was inclined to regard this section as belonging to the Coal Measures.

In 1870 the Sandwell Park sinking proved 575 feet of purple sandstone and marls, with 12 inch *Spirorbis* Limestone at 369 feet, while 670 feet below the base of red rocks occurred the Staffordshire thick coal, and Mr. Cantrill points out that the limestone of Sandwell must be on a higher horizon than that occurring at 50 feet below the base of the red rocks at Halesowen, as the former had been removed by denudation.

In 1875 two beds of limestone were discovered in the Hamstead Pits, the first at 558 feet, 12 inches thick (without

* *Q. J. G. S.*, 1895.

† Geol. Surv. South Staff. Coalfield, 2nd Ed.

Spirorbis), the next at 1,024 feet (with *Spirorbis*) 8 inches thick, the base of the purple measures being 1,353 feet. Mr. Cantrill considers the Upper Limestone, from examination of the specimen, to be undoubtedly a *Spirorbis* bed, in which I concur, having had the opportunity of studying the sample of the sinking preserved at the colliery, through the kindness of Mr. Meacham.

Mr. Cantrill points that there is no stratagraphical break between the fossiliferous portion of the South Staffordshire red series and the unfossiliferous portion, that the fossils have an Upper Coal Measure facies, that though a sudden change of colour takes place when the yellow beds come in, there is no unconformity.

From official reasons I am not at liberty to give any details of my investigations of the North Staffordshire Coalfield at present, but I may state that my experience in that district, and those portions of Worcestershire, South Staffordshire, and Warwickshire, makes me confident that Mr. Cantrill is correct as to the age to which he refers the whole of these red rocks. Though, as regards the southern end of the area, the striking resemblance to the Rothliegende trappoid conglomerates is so marked that it is difficult not to believe that they are of that age, and it is worthy of note that Credner had already, in his classification, prepared the way for such a view.

Mr. Cantrill's investigations in the Forest of Wyre have thrown great light on the Salopian type of Permians of Dr. Hull, which in the Enville area consists of :—

		Feet.
3.	Upper Sandstones and Marls	300
2.	Trappoid Breccia, alternations of Calcareous Conglomerates, Marls, and Sandstones ..	200 (variable)
1.	Lower Sandstones and Marls	850

Mr. Cantrill has discovered *Spirorbis* Limestone in 19 localities and thin coal seams in the red measures, but from

his paper it would appear that these beds are probably only 200 to 300 feet above the ordinary Coal Measures, it is worthy of note that if they be not more than this their presence is restricted to the lowest division of Hull's classification given above, and that consequently we have another example of a possible red Rothliegende lying on red coal measures overlying yellow and grey ordinary Coal Measures, and in this connection it is important to observe that the vast thickness of purple coal measure marls overlying the Potteries coalfield is older than the yellow and grey beds referred to above, and reviewing the whole of the circumstances. I am of opinion that the trappoid breccias of Worcestershire and their associated calcareous conglomerates are of Rothliegende age, and that the beds beneath are, as stated by Mr. Cantrill—Upper Coal Measures. That in Warwickshire and northwards the Rothliegende are absent; but the *uppermost Coal Measures* are of great importance. That in Lancashire the Zechstein Permian occurs for the first time, and rests on all members of the carboniferous alike.

Lancashire.—In 1854, Professor Hull, in a paper read before this Society, subdivided the Bunter into three, a central massive sandstone with pebbles passing in some districts with soft sand and loose shingle, overlaid and underlaid by soft variegated sandstones. He described the series as the Upper Mottled Sandstone, the Pebble Beds as the Lower Mottled Sandstone; these subsequently formed "f_3," "f_2," and "f_1" of the Geological Survey.

As regards the lowest number of the series, it is important to note Professor Hull's description of the Collyhurst Sandstone east of Manchester (Memoirs Geological Survey. "The geology of the country around Oldham, 1864"), he thus describes the section at Mr. Buckley's quarries, where the material is wrought now as then for iron foundry moulding—

a nearly uniform mass of bright red, orange, and mottled sandstone, soft and friable, and generally fine-grained. There are no pebbles in this sand. The whole formation is extremely like the Lower Mottled Sandstone of the Trias, from which it would be impossible to separate it, were it not that it underlies the fossiliferous marls of a Permian age. The rock is traversed by planes of current bedding.

During the past few years numerous facts have accumulated that lead one to suspect that Professor Hull's appreciation of the absolute identity of character of the typical Lower Mottled Sandstone of supposed Triassic age with the Permian Collyhurst Sandstones was due to the fact that they were really one and the same deposit, and that the supposed Lower Bunter was older than the *Schizodus* marls of Permian age, which are absent over wide areas through contemporaneous denudation.

In February, 1879, I gave to the Society the results of my study of the Bootle boring of the Liverpool Corporation Waterworks Committee, I then had no reason to suppose that the Lower Bunter did not exist, as I wrote as follows:—"The character of the Pebble Beds is well seen in this quarry in which the old well is sunk, and in the large quarry higher up the hill, from which it is evident that the thickness of this division of the Bunter is not less than 1,200 feet, instead of 600 to 800 as anticipated, the base of the Pebble Beds occurring in the boring at 1,039 feet, where the Lower Mottled Sandstone was first penetrated, the well-known 'millet seed grain' being specially characteristic. This is well seen in the Lower Mottled Sandstone of the Vale of Clwyd. The Lower Mottled Sandstone in the Bootle boring becomes very hard and compact at 1,228 feet from the surface, being cemented together by lime, for the grain when the rock is broken up is the same."

In 1880, in a further communication to the Society, I

stated that the base of the lime-cemented millet seed grained sandstone had not been reached when the boring was stopped at 1,334 feet, and stated that I recognized in cores, kindly shown to me by Messrs. Timmins, of Runcorn, from the Winwick boring of the then Warrington Water Company (now acquired by the Corporation), the Bootle hard rock, which overlaid beds of soft running sand with iron pyrites, with much water, and bands of marl overlying Upper Coal Measures, the beds intervening between the base of the Trias and the top of the Coal Measures being 200 feet in thickness.

In 1889, in the 14th Report of the Underground Water Committee, I pointed out that analyses made by Mr. A. Timmins, C.E., F.G.S., of the rock from the Portico Lane Bridge boring of the L. & N. W. Railway, near Huyton, were identical with the bottom rock of the Bootle boring made by him, and I stated that Bootle Beds are absent at Gateacre, the Pebble Beds resting direct on the Coal Measures. Also that in the Kirby boring of the St. Helens Corporation Waterworks, 107 feet of sandstone occur below the base of the Pebble Beds, and contain nodules of sulphate of iron, as at Parkside, Winwick, and Collins Green. The top sandstones of the Collyhurst type occur in the Knowsley boring of the St. Helens Corporation Waterworks, associated with marls. Unfortunately no Permian fossils occurred, but there can be no doubt as to the age of the series. In the 16th Report of the Underground Water Committee, 1890, the intermediate beds at Winwick, Knowsley, Collins Green, and Parkside are definitely referred to the horizon of the Permian Collyhurst Beds of Manchester.

During 1893 a very striking proof of the correctness of the views that have been step by step arrived at, as information steadily increased, has been afforded by the No. 3 boring at Parkside, near Newton-le-Willows, put down for

the L. & N. W. Railway Company, by Messrs. Timmins & Sons, Limited, of Runcorn, in which the hard dark lime-cemented *Sandstone* overlying the Soft (so called) Lower Mottled Sandstones has been found to contain well-preserved specimens of *Schizodus obscurus.*

This discovery is exceedingly important, as showing first that the fossil mollusca, usually occurring in the Magnesian Limestone, or in the associated Calcareous Marls, may be found in the sandstone beds of the same series.

Second, that the fossil in question occurs above the horizon, that was previously believed by many to form the base of the Trias.

Third, that fossils occur in the Zechstein Permian Sandstones as well as in the Permian Marls, and point to general uniformity of conditions throughout the whole period of the deposition and formation of sandstone, soft sands, marls, and magnesian limestones, extensive contemporaneous erosion having continuously taken place, operating from west to east. The very numerous borings in the Stockport area have been carefully studied by Messrs. Gray and Kendall, the results of which support the views arrived at from the investigation of the country between Liverpool and Manchester, and it would be advisable to call the important series of Permian sandstones, marls, and their conglomerate bands, "the Stockport and Clayton Vale Series" reaching a thickness of nearly 1000 feet, occurring *below* the Permian marls, with magnesian limestones.

Studying the Geological Survey Maps of the Triassic areas, between Worcestershire and Lancashire to the north, and Nottinghamshire to the north-east, the so-called "Lower Mottled Sandstone," will be found to be constantly absent, the Pebble Beds resting direct on the quasi-Rothliegende, or, this being absent, on the more ancient Palæozoic rocks, it will be found to reappear in considerable thickness, and its

presence and absence is seen to closely follow the occurrence or otherwise of the older quasi-Rothliegende rocks, the conclusion appears to be inevitable that it is of quasi-Permian age, and has been locally contemporaneously denuded, as well as the underlying quasi-Rothliegende (?) (Upper Coal Measure). It is interesting to note that the hard *Schizodus* sandstone, overlying the soft sands at Parkside, would have been a few years ago at once referred to the Bunter, which accords with Murchison's comparison of statement that the same species of Plants and Prœtorosaurus occur in "the marls, sandstones, and conglomerates lying above the Zechstein in Russia," as occur below it in Germany, and Murchison's further statement that the so-called Lower Bunter of the country north-east of Frankfort is in reality the uppermost Member of the Permian, overlying the Zechstein. If this theory be correct the so-called Lower Mottled Sandstone is sometimes older and sometimes newer than the Zechstein fossiliferous Marls, and in this case is the only member of the Zechstein Permian in the West Midland Counties.

The contemporary erosion and current bedding which characterise the Permians of Lancashire and Cheshire are present in the overlying Bunter and Lower Keuper Sandstones, but the erosion sustained over Worcestershire, Shropshire, Staffordshire, Cheshire, Derbyshire, and Lancashire is far less extensive than that that previously took place, but there is no break in continuity of physical conditions between the Permian and the Bunter, or indeed between the Permian and the top of the Lower Keuper Sandstone, "f_4" of the Geological Survey, the break and entire change of method of deposition taking place at the base of the Keuper Waterstones, "f_5" of the Geological Survey, above which no physical break occurs either at the base of the Keuper Marls, that of the Rhœtic, or that of the Lias, in Cheshire and Shropshire.

ANALYSIS OF FACTS AS TO PRE-TRIASSIC RED ROCKS.

Farnes Rocky	Dolomitic Limestones	60	....	[illegible]	[illegible]
	"Crab-rock," Hæmatite	20	....		
Barrowmouth	St. Bees Snes. brick red, Shale, Way-boards	1000 (*)	Nil.	Up. C. Mrs.	Sedgwick.
	Red and Green Marls, Gypsum..	30	....		Binney.
	Schizodus Lne. (Magnesian)	11	....		Harkness.
	Breccia	3	..		....
Appleby, Hilton Beck .	St. Bees Snes., Shale, Way-boards, with Plants	700	Nil.	Carb. Lne.	Brockbank.
	Hilton Shales Plants, Mag. Lne.	200	.. .		Harkness.
	Dol. Breccias and Penrith Sne., current-bedded	1500	....		Binney.
	"Brockram," Cong. Lnes. in Choc. Matrix	600	....		....
South Yorkshire	Upper Marls, Snes., and Gypsum	50	Bunter	Coal Mrs.	Green.
	Brotherton Lne., Marl & Gypsum	120	....	....	....
	Middle Marl, Snes, and Gypsum	50	....	....	....
	Small-grained Dolomite	200	....	....	...
	Compact Limestone, or Lower	120	....	....	....
	Marl Slates	15	....	....	....
	Quicksand	20	....	....	....

* These beds are now referred to the Trias.

Mr. Joseph Dickinson said: I have very great pleasure in moving a vote of thanks to our old friend and Honorary Member, Mr. De Rance, for the exhaustive paper he has presented in which the Permian question is thoroughly analysed. It was only at our last meeting that I had to ask the question—What were the Permians? There had been so many of these quasi-Permians introduced of late years by different writers, that really we outsiders did not know where we were. It is well enough for geologists like Mr. De Rance, who is a geologist by profession, and who has noted all the different changes in nomenclature introduced into geological study, but we, whom I have called outsiders, are not educated up to all the changes of names, which are being given. Mr. De Rance's paper this afternoon, however, thoroughly explains the whole matter. It shows what are true Permians and what are quasi-Permians, which ought not to be called Permians at all. He mentioned one particular point, in a paper by the late Mr. Davies, which was read before our Society a good many years ago on Coal in the Permians. I think the paper is in our Transactions.

Mr. De Rance: It is in the *Quarterly Journal*, and there is a paper also in your Transactions.

Mr. Dickinson: It was discussed before our Society. I said at the time that it was an entire mistake for Mr. Davies to put this coal in the Permian. He mistook the red measures, which divide the North Wales and Shropshire coalfields for Permian, and called the overlying or higher part of the coalfield at Ifton Rhyn "Coal in the Permian." In Lancashire we have really no such division; but we have very thick beds, generally sandstone, red in colour, and sometimes as much as 50 yards in thickness. But they are scattered about, and not in one mass as in North Wales and

North Staffordshire. Those red measures have led many practical men astray. They have been called Permian, whereas they are really Coal Measures. At our last meeting the question was raised: "Are the Permians conformable with the Coal Measures?" I said they are not conformable. They are clearly not conformable. If you take the Permians as we have them in this immediate neighbourhood, beginning, for instance, west of Manchester; we find them lying on the top of the 4-foot seam; but as you go westward, before you have got to Wigan, or St. Helens, you have got them lying on Coal Measures—300 yards lower—yet the same Permian, overlying unconformably. And the same takes place in the Durham coalfield. The Magnesian Limestone is called the Permian there. It is not conformable with the Coal Measures. On this point I would like to put a question to Mr. De Rance—I know it is one he can answer—What were the Permians in the Province of Perm (about 2,500 miles eastward from the district of which we are now speaking) with which Sir Roderick Murchison correlated the Magnesian Limestone and the Measures which we call Permian in Lancashire? The Permians of Lancashire are chiefly red or buff-coloured; whilst the Magnesian Limestone is entirely different. There is no resemblance between the two. The Lancashire Permian marls are about 180 feet in thickness; the Magnesian Limestone is 878 feet. If Mr. De Rance can explain what the rocks really were from which the name of Permian was derived we shall know better what the rocks are that we are talking about. I see a gentleman present (Mr. Caldwell) who has recently sunk through the Lancashire Permians. They find in them (specimens shown) flat nodules of limestone and the characteristic fossil shells, identical with those in the magnesian limestone in the County of Durham. The fossil shells are the only points of identity between the Lancashire and the Durham Permians

(that is, the Magnesian Limestone), and upon that one point of identity I think we call the Magnesian Limestone Permian, and we call these Lancashire marls Permian; and the Rothliegende, which lies down below, we call that Permian sandstone. To show that we are not to place too much reliance upon fossils, I would ask anyone who is a fossil geologist to look at the beautiful set of fossils on the table sent by Messrs. Barnes and Holroyd. They will find amongst them fossils which a few years ago were not supposed to go lower down than the Mountain Mine series of the Lancashire Coal Measures; but Messrs. Barnes and Holroyd's paper traces them down to the Millstone Grit.

Mr. Holroyd: And the Yoredales.

Mr. Dickinson: What reliance then is to be placed on the evidence of fossils? It is necessary to have the stratigraphical as well as the palæontological evidence before you can say that you are absolutely certain of the position and the identities of the principal strata.

Mr. Holroyd: I have great pleasure in seconding the vote of thanks to Mr. De Rance. When I began the study of geology, I was much puzzled with the red colour of some of these carboniferous (upper coal measure) or quasi-Permian beds. I only trust that Mr. De Rance's paper, which is so full of information on the subject, will be printed *in extenso.*

The resolution was carried unanimously.

The President said: The paper we have heard is certainly a very valuable one, and it is one, I think, that will be fully appreciated by all Manchester geologists. I do not know whether Mr. De Rance has come to any final conclusions upon the matter, but it is one that has troubled a good many of us—the relation between the Permian and

the Upper Carboniferous. Mr. De Rance has referred to the papers that were written by Mr. Brockbank and himself at the time when the cutting at Fallowfield was made. We had there a revelation certainly unexpected by many; we had a series of these beds of the Upper Permian, or Zechstein, opened out, samples of whose fossils were submitted at the time to Prof. Geinitz, of Dresden, and his determinations are incorporated in papers by Mr. Roeder and the Professor himself, published in the Transactions of our Society during the years 1890-91. The Spirorbis Limestone, which was thought to be a good base for Mr. Binney in tracing some of the Upper Coal Measures, now appears to be found lower down, and higher up in the Coal Measures. In Vol. VI. of this Society's Transactions you will see a diagram given by Mr. Binney, of the different occurrences of this Spirorbis Limestone, where it is shown to occur in some Scotch beds at a much higher level than with us. The recent explorations that have taken place in the Midlands have yielded much valuable matter as to the position of these Spirorbis beds, which seemed to want incorporating—as Mr. De Rance has so well done—with the knowledge previously obtained. The question has been asked: What is the Permian? I cannot quite agree with Mr. Dickinson that we are not to place much reliance on the evidence from fossils.

Mr. Dickinson: Not too much.

The President: For they are certainly, I consider, a very good guide as to geological age. I speak more particularly of the Schizodus and other typical shells of the Permian.

Mr. De Rance, after acknowledging the vote of thanks, said: First, in regard to Mr. Dickinson's question, whether we have any true Permian. If you draw a line from Not-

tingham to Birkenhead, in all the deposits north of that line, which are older than the Trias and newer than the Carboniferous, you have Zechstein Permian. You get these in North Cheshire, in South Lancashire, in Nottinghamshire, in Yorkshire, and in the Durham coalfield referred to by Mr. Dickinson. There is the Magnesian Limestone, which is equivalent to the Dolomite of Germany; and it has the same fossils as in Germany. As Mr. Dickinson has very correctly pointed out, in South Lancashire the limestones are dwarfed, thin, and insignificant; but there they are, and the fauna, so far as they contain a fauna, is what it should be. The labours of many geologists in the Manchester area have shown that the marls associated with these thin limestone beds contain the same shells as are known not only in Germany but in the Province of Perm, as shown by Dr. Geinitz in a paper published in the Transactions of this Society. In Germany, as I showed, the Permian had been studied before Sir Roderick Murchison went to Russia. It took the name of Dyas—the Zechstein above, and the Rothliegende below,—but in Bohemia the lower portion dwindled away; consequently the term Dyas was inapplicable in the Teutonic area. Still more in Russia was it inapplicable, because in Russia the fossiliferous limestone occurs mostly at the top—the Schizodus and other things being present—alternating with sandstones and marls, these last being associated with thin coals as base, and with gypsum and rock-salt, whilst underneath these are the productive Coal Measures, though the seams are very thin. My point was that the term Dyas is not applicable to the Permians of Lancashire or the Permians of Durham or Yorkshire. It is not applicable to the Permians of Bohemia, and not apparently applicable to the rocks we call Permian in Russia; but, for want of a better, we stick to the term Permian, and just as the fossils which are found in the

Zechstein—the true Permian—in Germany occur in Russia, occur in South Lancashire, and, for that matter, occur in Spitzbergen and places quite as far distant, it appears to me, looking at the doctrine of priority of names, it would be a great mistake indeed to call it anything else but Permian. But directly you get south of the line I have spoken of, ranging from Nottingham to Birkenhead, you get into an area in England where there is not a single ounce, or a single inch, of Zechstein, and in which not a single fossil has been found attaching to that group. It has been called Rothliegende, but it does not compare with the beds bearing the same name in Germany. That is to say, it is only the uppermost portion of it in Worcestershire—the rough trappoid breccias—that is comparable with what is known in Germany as Rothliegende. And that being so, I should be prepared to say that the Worcestershire type is Rothliegende; and that the Warwickshire are the uppermost Coal Measures. These measures are variable. They contain the Ifton Rhyn coal, and they contain also measures which in Lancashire and Cheshire are absent, but which, as shown by the Duke of Sutherland's boring, are present in North Staffordshire, this is the upper series of Coal Measures which we were not acquainted with before, having thought that because they were red they must be Permian.

The President: Do you consider the Magnesian Limestone beds of Durham an equivalent of the same thing?

Mr. De Rance: An equivalent of the Continental Dolomite, certainly.

Mr. Dickinson: Does Mr. De Rance consider that the fossil shells which abound in the Permians of Lancashire are identical with those in the Zechstein?

Mr. De Rance: Yes; the genuine article. In Dr. Geinitz's paper, published in the Transactions of this Society, the whole question is cleared up. I am the exponent simply of those who have gone before me.

In answer to a further question by Mr. Dickinson, Mr. De Rance said there was no Rothliegende in this country unless in North Worcestershire. Everything north of that was Upper Coal Measures or Zechstein. In the Permians of Russia, the Rothliegende was unknown.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART IX. VOL. XXV. SESSION 1896-97.

The ORDINARY MEETING of the Members was held on Tuesday, April 13th, 1897, at the Society's Rooms, Queen's Chambers, 5, John Dalton Street, Manchester.

The President, Mr. MARK STIRRUP, F.G.S., in the Chair.

NEW MEMBERS.

The following gentlemen were ballotted for and duly elected Ordinary Members of the Society:—

Mr. L. LAMB NOAR, The Grove, Lymm.

Mr. JOHN E. KEIRBY, Swinton, near Manchester.

Mr. BERNARD HOBSON, M.Sc., Owens College, Manchester.

In the absence of the author, the following paper was read by Mr. Robert Winstanley, C.E.:—

NOTES ON THE SINKING AT THE MAYPOLE HOUSE COLLIERY, ABRAM; WITH SPECIMENS OF ROCK, AND AN ANALYSIS OF THE WATER FOUND IN THE SHAFTS.

By Mr. George Caldwell.

Some time ago, when passing through the Permian Marls in No. 1 Pit, I sent a few nodules ("mince pies") to the Society, through Mr. Robert Winstanley, who was then President.*

We have recently passed through the same Marls in No. 2 Pit, where we found similar flat nodules. The band of Permian Marls is 10 yards thick, and from 94 to 104 yards from the surface. The nodules occur in a particular stratum, about two yards thick, at a depth of from 98 to 100 yards in each shaft. Below these Marls is 56 yards of Red Rock to the top of the Coal Measures, which, according to our borings, should be reached at a depth of 160 yards. The present depth of the shaft is 142 yards, and here we have struck a two-foot bed of sandstone, containing a large number of sulphur nodules or pebbles, about the size of large marbles, a few of which are here exhibited. When these nodules are burnt they smell strongly of sulphur.

We are now raising 120,000 gallons of water per hour.

The following is Mr. Orsman's analysis of the water, which is remarkable for the large quantity of Bi-Carbonate of Soda it contains. This analysis may be of interest to the Society; and from the accompanying Report it will be seen that Mr. Orsman speaks of the water as being of the Seltzer Water type. Some years ago, when the Wigan Junction Colliery Company were sinking through the same strata, in the same neighbourhood, their analyst described their water as Vichy Water.

* Trans. Man. Geol. Society, Part VII., Vol. XXIV.

Analysis of Water from Maypole House New Pits, Abram, now being sunk by Moss Hall Coal Company, Limited. Sample taken from Loaye, at 114 yards deep, per W. J. Orsman, F.I.C., F.C.S., Analytical Chemist.

Colour, in a tube 2 feet long: Faint greenish blue.

Suspended matter: Nil.

Smell, when heated to 100° Fah.: Nil.

Taste: Slightly saline.

Hardness, before boiling: 5°; Ditto, after: 1·4°.

Total solid matter: 44 grains per gallon.

Loss on ignition, not deducting Carbonic Acid: 11 grains per gallon.

Total mineral matter: 33 grains per gallon.

Chlorine (= to Sodium Chloride): 7 grains per gallon.

Lead: Nil. Copper: Nil. Iron: Nil.

Lime: Present as Bi-Carbonate.

Magnesia: Trace only.

Alkaline Salts: Present as Bi-Carbonate of Soda.

Sulphuric Acid—as Sulphate: Trace only.

Phosphoric Acid: Nil.

Nitrogen—as Ammonia: Nil.

Do. as Albuminoid Ammonia: 0·01 parts per gallon.

Do. as Nitrates: Nil.

Oxygen, absorbed by organic matter from solution of Permanganate of Potash—

At 80° Fah., in 2 minutes: Nil.

Do. in 4 hours: Trace only.

Microscopical results: Nil.

Mr. Orsman, in his Report, says:—"It is very remarkable in character, resembling the water found in many German mineral springs, principally near the Rhine."

"The water contains Chloride of Sodium and Bi-Carbonate of Sodium, also a trace of Bi-Carbonate of Lime, which easily separates out on standing or boiling."

"The water is very free from organic matter, and is very soft, and would make a first-class drinking water."

"It would be especially valuable for the manufacture of mineral waters."

"The water has no action on lead, but would rapidly cause iron to corrode."

Mr. H. Bolton wrote as follows: By the kindness of Mr. Tonge I have been enabled to examine the nodules from the Maypole House Colliery. They are extremely interesting. Each nodule consists of a number of well-rounded grains of sand, embedded in a fairly large mass of sulphide of iron as a cementing material. I am inclined to think that the sulphide of iron is that form usually known as Marcasite. The chemical composition of Pyrites and Marcasite is the same, but the crystal forms differ, and Marcasite more readily breaks up and forms iron sulphate. The history of each nodule would seem to me to be something like this. At first a uniform mass of well-rounded grains of sand existed, each with a coating of hydrated iron oxides, the whole forming an ordinary red sandstone. The passage of water containing sulphur (combined as sulphates) caused a conversion of the iron oxides into iron sulphide. This change would only occur at those places where somewhat unstable iron oxides existed. Oxygen was turned out from its combination with the iron, and sulphur took its place. Each point, where such a change occurred, would become the centre of growth of iron sulphide and induce similar changes of the iron oxide coating of adjacent sandgrains. The nodular form would be attained by this

gradually chemical replacement of oxygen by sulphur proceeding from a centre. You will notice that all grains of sand locked up in the nodules are clean, *i.e.*, they are *not* coated with a film of iron oxide. Their iron has combined with the sulphur. Not knowing all the circumstances under which the nodules were found I cannot say more than this, but I should suppose that with the replacement of the oxygen by sulphur there has also been a carrying into the nodules of some of the iron which coated the grains of sand still outside them. I should expect to find the sandstone in the immediate neighbourhood of the nodules, somewhat loose and deficient in cementing material.

Mr. Winstanley said he thought that to those who were interested in coal mining and sinking operations, Mr. Caldwell's communication was very important. He regarded the sinking operations at the Maypole Pits specially interesting, in that they showed what could be done by engineers with—he was going to say, pluck and perseverance. The quantity of water dealt with in connection with these sinkings had been simply extraordinary.

Mr. Tonge, in moving a vote of thanks to Mr. Caldwell for his contribution and sending the interesting rock specimens, said that Mr. Caldwell had been anxious the Society should possess what information he could give relative to this sinking, and the Society was greatly indebted to him. Mr. Caldwell had been at considerable trouble in collecting so many interesting specimens and sending them to the Society's rooms for examination. Mr. Tonge desired in the resolution to recognise Mr. Bolton's kindness in examining the nodules microscopically.

A Member seconded the motion, and in so doing informed the meeting that it was Mr. Caldwell's intention to send to the Society a complete section of the sinkings from the surface—a complete detailed section.

The resolution was unanimously adopted.

Mr. J. Dickinson said he had seen the Maypole Pit sinkings, and was able therefore to confirm the view as to their interesting nature. They went through a portion of the Upper New Red Sandstone, and below that they went on to the Permian marls, which contained numerous beautiful fossil shells, of which one on the table was a sample. Below these Permian marls they get this soft sandstone which was yielding the enormous quantity of water, which, if he gathered the figures rightly, meant about 2,000 gallons a minute, or 120,000 gallons per hour. That was not the highest point, for in some parts of the sinkings the workers had had to deal with considerably more than that. The Permian Marls with soft sandstone underneath which overlie the Lancashire coalfield are without doubt unconformable with the coal strata. Mr. Caldwell, I know, is aware of this, and he has had experience that the dip of the Permians is sometimes steeper than the dip of the coal strata. The dip of the respective formations should therefore in all instances be ascertained as carefully as possible, in order that workings in the coal may not be extended to the junction and become inundated. The feeder of water in the sandstone at this Maypole House winning is, as described, very heavy. An enormous feeder of, I think, about 600 gallons per minute came in this way some years ago into the Botany Bay Pits at Clifton, in Lancashire, but fortunately it admitted of being dammed out, which was successfully done and has so continued until now. It was, with the view therefore of having such like information recorded in our Transactions, that I used my endeavours to induce Mr. Caldwell to give us his information, which is very valuable. The Transactions of the North of England Institute of Mining Engineers in Vol. V., give similar valuable information respecting the great feeders of water

in the Magnesian Limestone, and underlying soft sandstone which overlie the coalfield unconformably in the County of Durham. The dip of this Magnesian Limestone and sandstone is at some places steeper than that of the coal strata. And whilst working to the south in the Low Main Seam at Castle Eden, a very few years ago, they apparently came to the junction of the Coal Measures with the Limestone, when they met with the sand feeder of water, which in a few weeks filled the workings, and rose to its level in the shaft, before they could get the materials out, including 14 steam engines, &c., valued at about £20,000 which were left underground. Members would see, therefore, the importance of having the sinkings through these over-lying rocks recorded in the Society's Transactions for the benefit of their successors who would have to sink through these strata.

Mr. Henry Hall said he had seen the sinkings referred to by Mr. Caldwell very frequently, and knew pretty well what had been done; but concerning the geological features of the work he was sorry he could not give the meeting much information. He could bear out what Mr. Dickinson had said with regard to the red rock. He remembered where it came in near the Huyton collieries. Over a distance of 100 yards horizontally the red rock thickened 50 yards, while the coal seams, visible and working, only ran down about half the steepness of the red rock, so that the coal seams were being rapidly cut off by the red rock, except perhaps the deeper seams. With regard to this particular sinking the water difficulty had been tackled with great spirit, and seemed to have been overcome. With regard to the nodules he wished to know why they were so round, and would be glad if anyone could enlighten him on the subject.

The President: Where do these nodules come from?

Mr. WINSTANLEY: From the red rock, about 20 yards from the present bottom of the shaft.

The PRESIDENT: These "mince-pie" nodules are certainly a most interesting exhibit, and I think the geologists and others must take notice of them. They are not peculiar to the Permian Marls; concretions of similar character occur frequently in sandstone, and you get them in many other of the stratified rocks. I took a broken portion of one of these nodules the other day to test it. They are all strongly calcareous, and it is the nature of lime to aggregate itself into this form when in rocks of other description, such as clay or sand; and there is here a crystalline fragment, which I take to be magnesian limestone. So there are carbonates of magnesia and lime, no doubt, in these nodules. The question arises whether they are formed at the time when the rock was being laid down, or whether it is an after-change. I think it is very likely the nodular formation went on at the time the rocks were being laid down, as it has been noticed often that calcareous waters turned out on soft clayey land have produced accumulations which take up this nodular form and crystalline structure.

Mr. HALL: There must have been some motion, I should think, to bring about this formation.

The PRESIDENT: No; I think that idea is wrong. The roundness is owing to the nature of the minerals which aggregate as a rule around centres, and it is simply a coming together of minerals of a like kind in rock which is of a different character, that is, for instance, clay or sandstone. All these nodules, you will find, are strongly calcareous. I do not think there is any motion at all required to account for their shape. You would suppose, Mr. Hall, they were formed by some movement?

Mr. HALL: Yes, probably by a twirling motion of some kind.

The PRESIDENT: No. The roundness is due to the tendency that lime has to form round a centre.

Mr. HALL pointed, in support of his view, to the instances of little stones found in the hollow, it might be, of a larger stone in the bed of a stream. The current, unable to wash the little stone away, moved it about with a twirling motion, day and night, until the stone became round, and he had a notion that these nodules had been formed somewhat in this way. "I do not think," Mr. Hall added, "you can get the spherical unless you have motion."

The PRESIDENT adhered to his view that motion was not at all necessary to bring about these globular shapes. Roundness of form might undoubtedly be made in the way suggested by Mr. Hall, but that had nothing to do with the making of these nodules.

Mr. DICKINSON: These little globular "pyritic" nodules should be distinguished from the cakes of limestone. These cakes of limestone—of which there are several specimens on the table—which Mr. Caldwell in his paper calls "mince pies," because they were found on Christmas Day, come from the Permian marls, but these nodules, the iron pyrites, come from the sandstone down below; and in being iron pyrites they certainly differ from many ordinary nodules which are found in the lower flag rock underneath the rough rock grit. Those, however, that have come out of the flag rock are sandstone—they are not iron pyrites like these. There is a marked distinction between them.

Mr. HOLROYD said some experiments had shown that it was possible to make a number of round stones without having them rolled about in the water, and without resorting to any particular chemical action. That was to say that many of these nodular forms could be produced by entirely physical means, and without the rolling action of water

suggested by Mr. Hall. The nodules found by Mr. Caldwell were formed by the gathering together of metallic particles round some common centre—usually a piece of decaying organic matter.

Mr. HALL said that miners were very familiar with iron pyrites; they presented themselves in two or three different forms—usually in flat layers, at other times in veins. He quite understood that these particles were wont, like birds of a feather, to flock together.

The CHAIRMAN confirmed Mr. Holroyd's view as to the way in which the nodules might be formed. As to the age of some of them there was, he said, a difficulty in deciding. They had on the table some examples from the glacial drift which had been dug out during the recent building operations near the Manchester Cathedral. One of the layers of earth there was filled with a number of these nodules. There was no doubt those were a very much later formation than such as they had from the Permian rocks.

NOTES ON THE YORKSHIRE COALFIELD.

By Mr. RICHARD SUTCLIFFE.

The Yorkshire coalfield, as at present known, is merely the northern end of the Great Midland coalfield; but whether it will always remain so or prove to be a connecting link, having the greater portion of its area concealed under the newer formations, between the Midland and the Great Northern coalfield of Durham and Northumberland, is still a question for the future.

The regularity of the field with its easy gradient, dipping generally eastward, and its comparative freedom from great faults, greatly facilitates the geologist in correlating its

different seams, and consequently we find the existing geological maps to fairly represent the several seams as they are found; more especially are the geological surveyors to be congratulated in having been able to assign the two apparently very different seams, namely, the "Silkstone" of South Yorkshire, and the "Blocking Bed" of West Yorkshire—the lowest seam of the Middle Coal Measures—to the same horizon at a time when there was no apparent connection between them so far as the coal seams themselves were concerned.

Although the general dip of the field is easterly, there are several anticlinals, all of easy inclinations, running pretty much east and west, which, with their corresponding synclinals, seem to have in some cases deceived the surveyors who marked faults or supposed faults on the maps where none existed, in order, I suppose, to allow sufficient depth to admit seams where they found them.

These undulations in the strata cause frequent local dips, either north or south, which, when taken in conjunction with the main easterly dip, frequently make the general dip at a colliery to be south-east or north-east, and sometimes when a colliery is spread over a large area the seams are found to dip in both directions.

It sometimes happens that a river running eastward cuts into the ridge of an anticlinal, causing the seams to crop much farther to the east than otherwise would have been the case; and it is a case of this kind which seems to divide the South Yorkshire and West Yorkshire names for the different seams. The South Yorkshire names are applied to the seams as far north as the valley of the Dearne at Clayton West, which is a village some seven miles west of Barnsley, where what remains of the very valuable "Silkstone" seam crops out, and is no more heard of as the Silkstone to the north of

that river. It assumes the less known name of the "Blocking bed," which it retains for a considerable distance to the north.

This seam, Professor Hull says ("Coalfields of Great Britain," page 255,) "is undoubtedly identical with the 'Arley Mine' of Lancashire," and "has originally spread over a tract embracing not less than 10,000 square miles." It forms the lowest seam in the Middle Coal Measures, and therefore it appears to be a good index coal to start from, although there are some valuable beds between it and the Halifax or Ganister beds of coal below it, which not only may be of much value in the future, but are already supplying some useful coal for both domestic and industrial purposes, and they include the Whinmoor, Black Bed, Better Bed, and others.

The Silkstone seam is formed of two beds of coal, with a thin layer of dirt "parting" between them. It seems to have been found about at its best in the neighbourhood whence it takes its name, some four miles south-west of Barnsley, and it continues good in its southern extension right into Derbyshire, but at Cawthorne, two miles to the north, the lower bed, which is the softer of the two, disappears, and is not again found, although the upper bed continues as a thin coal of good quality almost to the northern extremity of the field, and is known as the Blocking Bed, as before stated. The line of deterioration of the lower bed of this seam is found to run in a south-easterly direction from Cawthorne, by Rotherham, to Kiveton Park.

Some thirty-five yards higher up in the strata is found the "Silkstone four feet" coal, which varies in thickness from four feet, as its name implies, to two feet or less. It is chiefly used, where worked, for commercial purposes—it being of rather poor quality, is not much used for house coal. It

reaches its greatest thickness also in the neighbourhood from whence it takes its name, but is missing altogether a short distance to the south. It extends in a northerly direction right to the extremity of the field, or nearly so. To the north of the Dearne Valley it is called "Wheatley Lime" and "Old Men's Coal."

Eighteen to twenty yards higher in the measures is also found in the same neighbourhood a seam of good coal known as the "Swilly Bed." It is said to have reached a thickness of nearly eight feet at Silkstone Falls, but its average thickness is from two to three feet, and like the "Silkstone four-feet" it disappears altogether to the south, but it spreads itself in a north-easterly direction, and extends to the extreme north of the field. North of the river Dearne it is known as the "New Hards," Middleton Main," and "Silkstone" coal. It has a rather marked resemblance to the South Yorkshire "Silkstone" top seam, and consequently the miners sometimes call it the "Silkstone tops." (However, the Silkstone four-feet is found at eighteen to twenty yards below it in both districts, and lying between them it is an infallible guide). It is a splendid seam at many places in West Yorkshire, and is at its best about Normanton, where it is found to be from three feet six inches to five feet thick.

The next seam in ascending order is the "Thorncliffe Thin" coal, from two to four feet thick, and like the two former it thins very much to the south. In West Yorkshire it is known as "Green Lane" or "Middleton Little" coal, and it retains its character as a thin coal throughout the western portion of the field, but it is not extensively worked.

Some twenty yards higher the useful and well-known "Parkgate" seam is found. Like the Silkstone it contains two beds of coal generally separated by a band of dirt, the

lower bed, about two feet thick, being a hard coal, and the upper bed a softer coal of 18 inches to two feet in thickness. It is of a large area, extending both north and south, but as it goes to the north the band of dirt thickens until it separates the beds by several yards. North of the Dearne Valley the under coal takes the name of the "Old Hards," and it has for a long time been highly prized as a red ash house coal of the first order.

There is a seam, known as "Fenton's Coal," found in the Barnsley district some 20 yards above the "Parkgate" seam, but it does not seem to extend to the south, and there is also a seam known as the "Flockton Thin" coal found 28 yards above the "Old Hards" seam near Wakefield, but whether they are one and the same seam is not yet fully known. They are from 18 inches to 2½ feet in thickness.

The "Flockton" coal is found about 50 yards above the "Parkgate" seam, and is common to both the South and West Yorkshire districts. It is the only seam retaining its name in both districts, but it is not much worked in either, and it varies from a few inches to three feet in thickness. It is a soft coal of fairly good quality.

Next comes in the "Joan" coal, some 20 yards above the Flockton seam. It is at present of no commercial value and it is not all over the field. It varies from a few to 18 inches in thickness.

The seam known as "Swallow Wood" in South and as "Haigh Moor" in West Yorkshire, is about 100 yards higher than the Flockton coal. In the southern portion of the field this seam is much neglected except around Rotherham, where it is a very valuable seam of five feet in thickness. It is, however, extensively worked all over the northern portion of the field, where it varies from two to 4½ feet in thickness, and produces that most excellent house coal known as the "Haigh Moor."

The next seam of importance in the series is the celebrated "Barnsley Bed," which is unquestionably the premier bed of the county. This remarkable seam of coal is made up of several beds, all of good quality, in the neighbourhood whence it takes its name. The lowest bed is about 2 feet thick, and produces house coal of good quality. Next comes the bed which supplies the widely known Yorkshire Steam coal, and it varies from two to four feet in thickness. Over it are found three beds of good house coal, each about one foot thick, making in all a solid deposit of coal of about nine feet in thickness, in the neighbourhood of Barnsley. Like most good things it does not last long, and at Haigh, five miles north west of Barnsley, the hard coal disappears, and is found no more to the north west of the field, while to the south it also thins down to about four feet south of Rotherham, and continues so into Derbyshire. The line of its northern deterioration may be roughly taken as north-east, say from Haigh to Pontefract, and to the north-west of this line the West Yorkshire name of Warren House coal takes its place. The "Warren House" seems to consist of the upper or house coal beds of the great Barnsley seam.

Seventy to eighty yards above the Barnsley bed a seam called the "Kent Thick" is found, and at some places it reaches a thickness of four feet, but it is not much worked.

The "Kent Thin" coal is found 25 to 30 yards still higher in the strata, and is of little value as yet.

"Beamshaw" seams, two in number, come in at about 25 yards above the "Kent Thin" bed in the neighbourhood of Barnsley, where the two seams are separated several yards by strata between them, but near Haigh they come together forming a seam about five feet in thickness. Further north they form the "Stanley Main" seam of West Yorkshire, where it has been extensively worked and found to be a very

useful coal. The measures between it and the "Warren House".coal at Castleford thin down to about 60 yards.

The "Winter" coal is next in order, and 12 to 25 yards higher up. It extends throughout the whole length of the field, or nearly so, and is seldom found to be less than two to three feet in thickness, and it is of good quality but rather soft. At Wakefield and farther north it is known as the "Scale Coal."

The "Summer" coal or "Two-feet" seam is situated 17 to 20 yards higher than the Winter bed. It is from 18 inches to three feet in thickness. North of Wakefield it is called the "Cat Coal."

"Wathwood" or "Woodmoor" coal is 18 to 25 yards above the "Two-feet." It is much like the latter in thickness and quality, and both are little used. North of Wakefield it is known as the "Muck" coal, being greatly split up by dirt bands.

About 30 yards farther up comes in the "Newhill" or "Steam" coal, 18 to 20 inches in thickness. It seems to be represented at Castleford by the "Bateson" seam, and it is not much used.

Forty yards higher up "Swinton Pottery" coal sets in, agreeing with the "Wheatworth" seam at Castleford, two to three feet thick, including some dirt partings. Two seams known as the "Sharleston Bottom" and "Top" coals are found within 150 yards of the "Swinton Pottery" coal.

The "Shafton" coal or "Nostell" seam is found some 70 yards above the "Sharleston Top" coal, or about 450 yards above the Barnsley coal, three to four feet thick, and of fairly good quality. It is the highest seam of importance found so far in the field, but in sinking Cadeby Main they found a seam two feet six inches thick, upwards of 700 yards above the Barnsley bed.

At present all thin seams above the Barnsley bed are much neglected, but no doubt a time will come when they will be all turned to good account, and the shafts sunk through them to the thick coal will greatly contribute to their extraction when required. There are also a number of thinner seams from six to eighteen inches thick, in addition to those above, which can be worked when wanted, and we have not to wait for the wane of our great industry to prove the practicability of getting these thinner seams, because they have already been worked down to six inches thick when the exceptional value of the coal, such as good cannel, was sufficient to cover the expense, and we are every day working it down to one foot thick. It only requires the price of coal to go up a few shillings per ton to enable the thinnest to be worked.

Neither is the increased temperature in the deep mines likely to be the great obstacle that some fear to the getting of thin seams, because it is more than probable that they will be all got by coal-cutting machines, worked by compressed air, and the discharge of that compressed air in large volumes will considerably lower the temperature at the faces. Even if there are no such machines used it will not be found impossible to convey compressed air to the working faces to lower the temperature there, and it may be found to be a point of economy to do so instead of ventilating as now.

Nearly all the seams found at Barnsley are represented in the northern portion of the field, but yet the measures containing them, taken as a whole, seem to diminish northwards. Those between the "Whinmoor" and "Woodmoor" coals in the Barnsley district amount to about 557 yards, and they thin down to about 440 yards at Castleford.

A Member, in moving a vote of thanks to Mr. Sutcliffe for his paper, said that no doubt it would prove a good record of the different mines referred to therein, and if it were supplemented with a diagram of the district it would be exceedingly valuable.

Mr. Dickinson seconded the motion, and in so doing referred to the hope expressed by Mr. Sutcliffe that the Yorkshire coalfield might eventually turn out to be connected with the Great Northern coalfield, meaning the Northumberland and Durham coalfield. He thought in that Mr. Sutcliffe was mistaken. So far as the explorations in the mines went in the Durham coalfield southwards, they pointed, he thought, in a different direction from that suggested by Mr. Sutcliffe. Moreover, in the calculations as to the quantity of coal likely to be obtained in the Durham county, by the Royal Coal Commission, it was assumed that the Yorkshire and Durham fields were not connected, and from all he knew it would be proved they were quite distinct.

The resolution was adopted.

The President said he agreed with Mr. Dickinson that correlation between the coalfields of Durham and Yorkshire was not to be looked for; it might, he thought, rather be expected between the Yorkshire and Lancashire fields, as there were indications of the unity of those fields prior to the time when the elevation of the Pennine range of hills severed the Yorkshire from the Lancashire coalfield. But when they got to Durham they met with a lot of limestone layers which came in and intercalated with the coal. Altogether it seemed to him that the coalfield of Durham was quite distinct from that of Yorkshire.

Mr. Dickinson referred to the great interest which Mr. Sutcliffe took in the development of coal-cutting machines.

Mr. SUTCLIFFE, in reply, disclaimed any idea of classing his paper among the important ones. He had thought it might lead to a discussion, and direct attention to some of the features of the Yorkshire coalfield. In Yorkshire they had, in his judgment, one of the most easily dealt with coalfields in England. The coal lay at a very easy gradient, and was little disturbed by faults. It must not be assumed that they had no faults. They had plenty, but few great ones, and he was happy to say no great failures. With reference to the supposed connection of the Yorkshire coalfield with that of Durham, he would have those who differed from him to remember that they did not as yet know what was below the bottom of the newer deposits.

EXHIBITION OF PHOTOGRAPHS, PRINTS, &c.

Mr. S. S. PLATT, M.I.C.E., F.G.S., exhibited a series of photographs, prints, &c., showing geological features. These views were explained, and Mr. Platt took occasion to urge the importance of members of the Society securing, whenever possible, photographic pictures of sections of the earth's crust.

A cordial vote of thanks was tendered to Mr. Platt for his exhibition and explanation.

The PRESIDENT directed attention to the very excellent collection of photographs of geological interest now placed in the Jermyn Street Museum, London, which had been got together by members of the various Corresponding Societies of the British Association acting under the guidance and authority of the Special Committee of the Association formed for that purpose.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART X. VOL. XXV. SESSION 1896-97.

WIGAN MEETING.

The ORDINARY MEETING of the Members was held on Friday, May 14th, 1897, in the Mining School, Wigan.

Mr. HENRY HALL, H.M. Inspector of Mines, (in the absence of the President,) in the Chair.

NEW MEMBER.

The following gentleman was balloted for and duly elected an Ordinary Member of the Society:—

Mr. THOMAS SCHOLES, 137, Rochdale Road, Royton.

DETONATORS AND DETONATION.

By Mr. W. J. ORSMAN, F.I.C., F.C.S.

The term explosion may be simply defined as the sudden liberation of a large volume of gas at a high pressure. For the economical getting of coal, especially in hard seams,

various explosives are used, and the following remarks are intended to explain the different methods whereby explosion may take place.

In ordinary explosion, as illustrated by the firing of gunpowder, we have certain elements and compounds in the solid state having great chemical affinity for one another, packed closely together, which on the application of heat, combine and form new compounds which are no longer solid but being in the gaseous state occupy an enormously greater volume than the original substance, and further, the gases liberated are largely expanded by the heat produced by the combination. For instance, one cubic inch of gunpowder will yield 270 cubic inches of gas, measured when cold, but at the moment of explosion the heat produced expands this volume of gas to 3,000 cubic inches, which if confined exerts a pressure of 30 tons to the square inch.

Gunpowder being comparatively a slow burning compound, the gases formed take some time to get up to the maximum pressure, and this circumstance makes gunpowder a valuable explosive when blowing soft seams of coal, as the slow development of pressure produces a heaving instead of a rending effect.

The decomposition of certain explosives can be brought about not only by the application of heat, but by exposing them to an intensely rapid explosive wave, causing an effect called detonation. This wave is set up when certain chemical compounds, such as Iodide of Nitrogen, Fulminate of Silver, Fulminate of Mercury, Nitro-glycerine, &c., the elements of which are very feebly combined, decompose. The decomposition sets up a series of vibrations which, travelling quicker than sound waves, cause certain compounds to decompose and split up into their elements, which may or may not combine together again. Mons. Berthelot,

in explaining the nature of the change, says that in the case of an explosive compound being in contact with a charge of fulminate of mercury, the whole of the explosion communicated to the layer of gaseous molecules in immediate proximity an enormous active force, whereby the molecular edifice was shaken to pieces, and the initial active force was augmented to a degree corresponding with the heat evolved by the decomposition of the gas. A new shock was thereby produced in the next layer, and the action was continued and so propagated until the molecular system was completely destroyed. In simple language, an explosive wave is capable of shaking some chemical compounds to pieces, and by selecting such compounds the elements of which are gaseous and combustible very powerful explosive results may be obtained.

Another point which is of great importance is the time taken to produce the above change. In gunpowder we have a body burning comparatively slowly and the accumulating gases gradually increasing in pressure. With detonating compounds the maximum pressure is attained in less than one ten-thousandth part of a second. It is this last circumstance, namely, the time during which a given force is exerted, that makes the high explosives so much more powerful than gunpowder. It is an erroneous idea that the extra strength of high explosives is due to their developing a very high temperature; as a matter of fact, the temperature is generally much lower, as the following table will show:—

	Degrees Centigrade.
Gunpowder (High Grade)	3,400
Gunpowder (Low Grade)	2,230
Blasting Gelatine	3,170
Dynamite	2,940

Roburite and other nitrate of ammonia explosives, about 2,100 degrees centigrade.

The strength is due then to the gaseous products of combustion being liberated, and exerting the maximum pressure almost instantaneously. The next point to be considered is the means by which the explosive wave producing detonation may be best initiated. All that is necessary is that the pressure and therefore the temperature should rise to a sufficient value at any one point of the mass, with certain bodies, for instance, fulminate of silver and iodide of nitrogen, the elements are so loosely held together that the slightest pressure is sufficient to cause detonation; but the ease with which the explosive wave is established is fatal to their use as detonation agents, for the wave is unable to start the detonation of bodies which are easily detonated by fulminate of mercury.

From experiment it has been proved that the best detonating results are obtained by the aid of fulminate of mercury. This is explained by the fact that fulminate of mercury (thanks to its high specific gravity of 4·2) is the most powerful, *i.e.*, energy liberating explosive per unit volume, and will exert a pressure of nearly 200 tons per square inch. It may be of interest to note that the most powerful explosive per unit mass (*i.e.*, weight for weight) is blasting gelatine, containing 92 per cent. of nitro-glycerine and 8 per cent. of gun-cotton.

It has been found that certain mixtures such as nitrate of ammonia, together with a nitrated organic body *(e.g.)*, the nitro compounds of benzole, toluole, and naphthalene can easily be exploded by detonation, but are totally non-explosive when exposed to the effects of fire, electric sparks, or percussion, and during the last few years a new class of

high explosives has been introduced called the nitrate of ammonia safety explosives, such as Roburite, Bellite, Ammonite, &c. These are remarkably safe to use on account of (1) their non-sensibility to fire by flame or percussion.

(2) The products of combustion are gaseous and non-poisonous.

(3) The total number of units of heat developed is much less than when gunpowder is used to do the same work.

The detonators of commerce consist of metallic capsules, resembling elongated percussion caps, and contain varying weights of pure fulminate of mercury, mixed with a small proportion of chlorate of potash. The weight of the latter substance should not exceed 5 per cent. when the detonators are used for firing nitrate of ammonia explosives. For firing nitro-glycerine compounds a larger amount of chlorate of potash is advantageous. On this account nitrate of ammonia explosives should never be fired with detonators intended for nitro-glycerine compounds, such as Dynamite, Gelignite, Carbonite, &c. Detonators are distinguished by numbers varying with the quantity of explosive they contain, thus:—

No.	1	contains	0·30	grammes of	explosive.
,,	2	,,	0·40	,,	,,
,,	3	,,	0·54	,,	,,
,,	4	,,	0·65	,,	,,
,,	5	,,	0·80	,,	,,
,,	6	,,	1·00	,,	,,
,,	6½	,,	1·25	,,	,,
,,	7	,,	1·50	,,	,,
,,	8	,,	2·00	,,	,,

Nearly all the detonators used here are made abroad, and last year about ten millions were imported into the United Kingdom.

For firing the nitrate of ammonia class of explosives, detonators containing at least one gramme of fulminate should be used, and for this reason Numbers 6, 6½, and 7 are in most general use. As mentioned above, the amount of chlorate of potash should not exceed 5 per cent., otherwise the strength of the detonator is greatly reduced. It has been found that a large number of the cheap detonators imported into England contain from 30 to 40 per cent. of chlorate, and are quite unfit for detonating the above class of explosives.

Great care must always be exercised when handling detonators, as the fulminate of mercury is very sensitive to heat or percussion, a temperature of 190° centigrade, or even pricking or scratching the fulminate with a steel needle will cause detonation.

When used for detonating explosives the detonators are fired either by tape fuse, or preferably on the account of safety by electrical methods.

In this district nearly all the firing is done by electricity, either by a low tension or high tension current. These currents are preferably produced by means of small hand magneto machines. The low tension system has one great advantage, namely, that the detonators can be tested before firing and provision so made against mis-shots. Other questions relating to the methods of electrical firing are rather beyond the scope of this short paper, and may be left for further discussion.

Mr. TONGE moved and Mr. DEAN seconded a hearty vote of thanks to Mr. Orsman for his interesting paper.

The vote of thanks was passed unanimously.

The CHAIRMAN said there were several points that were interesting in Mr. Orsman's paper. They had to make up their minds whether to use low or high tension fuses, but it struck him (the Chairman), that if they had got accustomed to use high tension, there did not seem to be any strong reason why they should change. The only advantage would be that they could test the detonators before firing, but the testing of the detonators by the firemen, seemed to be rather impracticable. It would be a wearisome process to have to put every detonator through the process Mr. Orsman suggested, and if not done carefully there would be considerable danger in doing it. If tested in the way suggested, it would have to be done experimentally after they had put the shot in the cartridge. Perhaps Mr. Orsman would clear up for them this matter of testing, and say whether they could actually test the circuit after the shot was ready to be fired, because if not it would not amount to much as the circuit might not be perfect, and having once put it in the shot-hole, if he tested it then, and found the detonator or circuit was wrong, could he correct it without drawing the shot. Mr. Orsman mentioned the varying power exerted by the different explosives. He should be glad if Mr. Orsman would tell them something as to what the effect would be in the way of force developed by a certain quantity of a mixture of fire damp and air, at its most explosive point. What he wanted to get at was, supposing a working place had explosive mixture in it for twenty yards, from the face backwards, would the ignition of this quantity of fire-damp and air be likely to blow up the colliery, or what would the effect be. He had heard some people say such a quantity

would be enough to play tremendous havoc, whilst others said it would have little or no effect. Fire-damp and air mixtures are said to increase their volume only some seven or eight times on ignition, whilst in the case of gunpowder the original volume on ignition was multiplied three or four thousand times. If that was true, it seemed to him that the actual force developed by the explosion of fire-damp and air would be trifling unless they had an immense quantity. Another point was that gunpowder could not be detonated. He should like to ask why other explosives could be detonated, and also why the detonators came from abroad, and were not made in England. Mr. Orsman also mentioned the fact that the lower grade gunpowders exploded at a lower temperature than the better class gunpowders. He would like to ask what his opinion was of the suggestion of gunpowder makers who told them that they could produce higher grade gunpowder which would be equally as safe as any of the so called safety explosives, whether he thought that was possible.

Mr. Dean: What would be the effect of firing an explosive with a stronger detonator than the one put down as being of the strength recommended by the makers? Some explosives were put down as requiring a No. 5 detonator, what would be the effect supposing it was fired with a No. 7 or No. 8? Was a stronger current required to fire a higher number of detonator? He understood the detonator acted equally well with a weak as with a stronger battery. Had Mr. Orsman any records of the percentage of missed shots from low tension and from high tension fuses? That seemed to be an important question.

Mr. Orsman, replying on the discussion, said: With regard to the question: Why cannot gunpowder be detonated?

The theory of detonation implies that compounds are first split up into their elementary forms by the explosive wave. In gunpowder you have the two combustible ingredients already in the elementary state, so that all detonation can do is to start combustion. The reason that a cartridge of loose powder burns more quickly when fired with a detonator is because the flame from the detonator strikes through all the cartridge, and so ignites the grains simultaneously. The reason why all detonators are made abroad is owing to the restrictions imposed by the English Government, principally on account of the Excise Laws. Alcohol, one of the chief ingredients in the manufacture of fulminate of mercury, is not allowed to be used in England for manufacturing purposes except the very heavy duty is paid as on potable spirits. In Germany the trade is not hampered in this way. The danger from gunpowder is not so much the temperature of combustion as the production of solid matter. Fifty per cent. of the fumes of gunpowder consist of solid particles which are projected into the air of a mine at a high temperature. The value of the high explosives is the fact of their nearly all being smokeless. Whilst most people, even manufacturers themselves, say that ordinary mining powder is dangerous on account of the poisonous and inflammable gases that are given off, the manufacturers claim that the danger can be eliminated by using high grade gunpowder. This means that the ingredients are more intimately mixed and proportioned so as to give complete combustion. This is principally accomplished by increasing the amount of nitrate of potassium. I cannot agree that such a mixture would be less dangerous than ordinary powder, in fact experiments point in the opposite direction. High grade gunpowder may mean less poisonous gas, but it also means a much higher temperature, and the solid products would be projected into the air in a much hotter state than from

ordinary mining powder. An excellent experiment to show the heat produced by powder is to lay say 8ozs. on the ground and cover over with a bag of coal dust. On firing the powder the coal dust is scattered and at once catches fire, producing an enormous volume of flame. When the same experiment is tried with Roburite not a spark is seen. To initiate a big explosion the principal circumstances are: 1st, a mixture of gas and air in the most explosive proportions; 2nd, such a mixture must be confined to a certain extent; and 3rd, the presence of combustible material in a condition to carry on the explosion. The chief value of being able to test the circuit in low tension detonators is that we are able to test them before stemming and so reject any that may be found to have faulty connections. Also in firing a number of shots simultaneously in series it is advantageous to know that all the connections are good. He had no statistics to show the relative number of missed shots in comparing high and low tension fuses, and further, that high tension exploders could now be made so as to register 120 volts, and that for general use the pressure of the current should not fall below 50 volts. No extra power is required to fire detonators of greater strength than No. 6. That is to say, detonators of No. 7 and No. 8 are as easily fired as No. 6, as the electrical fittings are fixed on a separate primer.

A NEW HYDRAULIC APPARATUS FOR BREAKING DOWN COAL IN MINES.

By Mr. James Tonge, C.E., F.G.S.

The apparatus submitted to the notice of the members to-day is another attempt to solve the problem of how to get coal without blasting; blasting being, in the opinion of the inventors, the greatest of all the dangers connected with mining. For though throughout a year there may be a greater sacrifice of life from other causes than blasting or explosion, yet when an explosion does take place it may, at one sharp stroke, wreck a colliery, and leave a little mining village without a house where there is not one dead. It was this thought that prompted the writer and his partner to attempt to find a substitute for blasting. They are perfectly well aware that laws regulating the use of explosives are getting more and more stringent, and tend to lessen the risks attending blasting; but they feel that the risks are still great, and the greater depths to be sunk to, with increased heat and greater quantities of dust and firedamp, will bring yet greater risks and necessitate further restrictions and costs in working, except improved methods of working and better appliances can be discovered; and such, it is hoped, the appliance shown to-day will prove to be.

The apparatus shown is what we term a hydraulic cartridge. It consists of—(1) The cartridge proper, 18 inches in length, 3 inches diameter, made of special steel, and weighing 30 pounds; and (2) a small but powerful hand pump of special construction, fitted with a pressure gauge and light adjustable stand, weighing 20 pounds; total weight, 50 pounds.

The mode of using it is as follows: The coal is holed underneath to the usual depth, and a hole drilled near

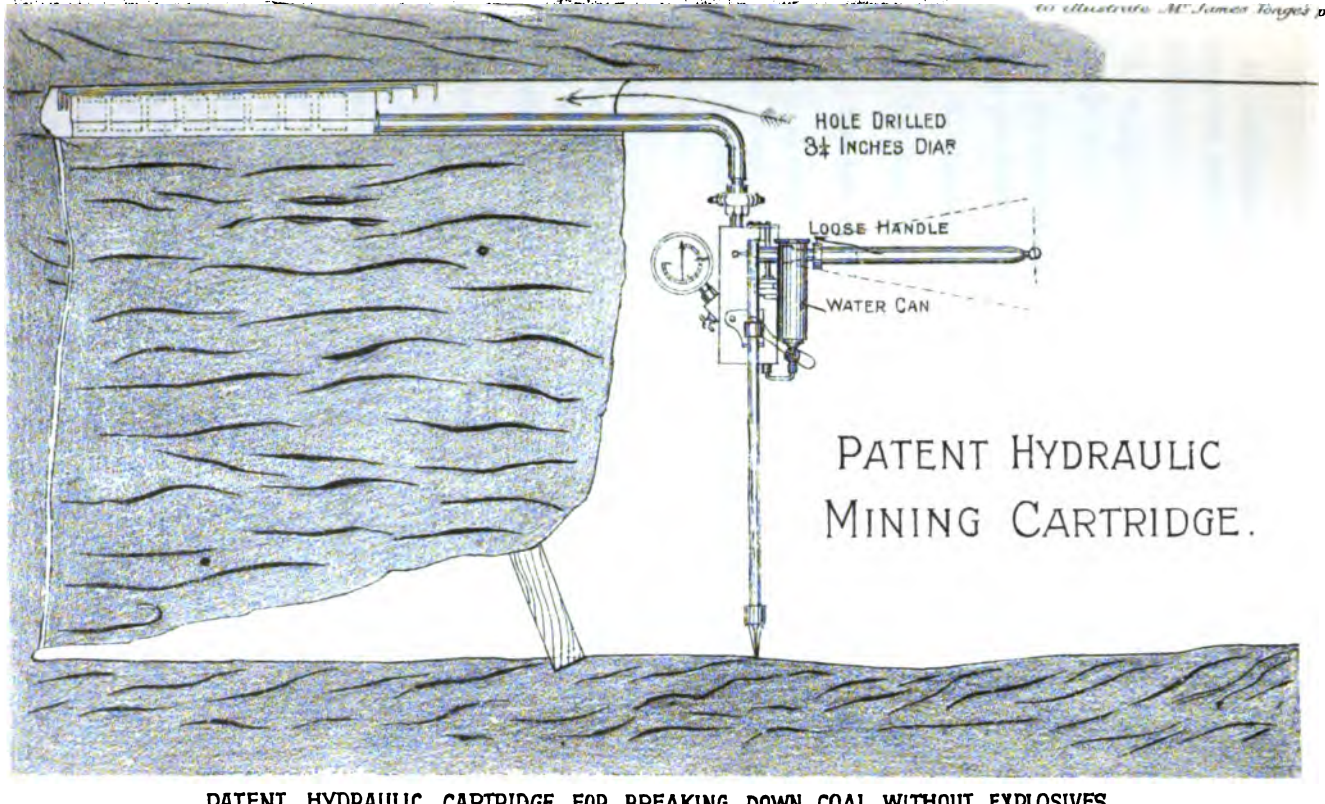
the roof to about the same depth as the holing, in the same way as if for blasting. When this has been done, the cartridge is put in the hole, and pushed to the back, no stemming is required; the pump is at once coupled to the cartridge, the suction pipe placed in a small bottle of water, and work commences. In a few seconds the cartridge is charged with water, the pumping being easy, and only the short handle being used. But when the pressure comes on a longer handle is slipped over the short one. In a very short time the gauge begins to show the rising pressure, half-a-ton, a ton, a ton and a half, two tons per square inch. During this time a cracking sound behind the cartridge has been telling that the pressures shown on the gauge have had the effect of shearing off the coal at the back, the sprags or holing props being kept in their place in front.

The gradual way in which the work is done, without shock or jar of any kind, prevents even the least damage or injury to coal or roof, in striking contrast to the action of explosives of any kind.

The time occupied in these operations is, of course, an important matter, and no doubt it will vary with varying conditions of the mines. The tests, so far, have occupied on an average something under 12 minutes. This time includes placing the cartridge in the hole, connecting to the pump, getting down the coal, withdrawing the cartridge from the hole, and getting to the next place.

The holes have been placed slightly farther apart than in the case of blasting, hence a slightly greater quantity of coal has been brought down at each operation than was brought down before by blasting, whilst the coal is both larger when it falls and is less liable to be broken into Small during transit because of not having been shattered by explosives.

Trans Min Eng Soc Lond A Vol XXV
to illustrate Mr James Forges paper



PATENT HYDRAULIC CARTRIDGE FOR BREAKING DOWN COAL WITHOUT EXPLOSIVES.

In conclusion, the experiments so far have yielded, as compared with powder or other explosive, the following results :—

1. Larger and stronger coal, which means a better average price.

2. No interference with the working of the pit, the coal being got down whenever required—night or day.

3. No damage to roof.

4. No dust.

5. Absolute safety from the dangers attending shot-firing.

It is, of course, gratifying to think that whilst endeavouring to secure *greater safety* in coal getting, an appliance has been produced which also promises *better coal* and *greater convenience.*

But the satisfaction of the inventors rests chiefly upon the fact that in this machine there seems to be the promise of a time very near when blasting in coal, with all its attendant dangers, shall be done away.

To an audience like this it may seem out of place to dwell upon the dangers of blasting ; but no one who has been in the mine when a fast shot with a heavy charge of explosive has taken place can soon forget it.

The writer was, on one occasion, present when such a shot took place in a large colliery with three mines at work connected by tunnels. Suddenly there was a rush of wind, instantaneous darkness, a loud opening and closing of air-doors, and a feeling that an explosion had taken place in one of the mines. We made our way to the shaft, and on reaching it found the men coming from the other two mines. After a few minutes further anxiety we were relieved to

find that nothing more serious than a fast shot, unaccompanied by fire-damp or coal dust, had taken place; but it was very easy to see that had these been present the colliery might have been a complete wreck, and the sacrifice of life very great. To render such disasters impossible has been the desire of the inventors (the writer and Mr. Gass) in the production of this machine.

The apparatus was explained by Mr. Gass and Mr. Tonge.

The CHAIRMAN: If Mr. Tonge can succeed, his apparatus will be the safest of all safety explosives, and we need not trouble our heads any further about detonators, &c. I should like him to give us a little more information about the practical tests the apparatus has already been put to.

Mr. WINSTANLEY asked for an explanation with regard to the cartridge. It seemed to him that it was an old friend in a new guise.

Mr. GASS: Yes, to a certain extent, but the defects in the old ones have been overcome in this.

The CHAIRMAN: Have you ever had a failure?

Mr. GASS: Only one, and then we had 60 tons pressure.

The CHAIRMAN: What is the pressure?

Mr. GASS: With this pump, 50 tons.

Mr. WINSTANLEY: How long have you been working with them?

Mr. GASS: Three or four months.

Mr. TONGE: It has in every case done what we hoped from the commencement.

Mr. WINSTANLEY: How many shot-holes would you want?

Mr. TONGE: About as many as if using explosives.

Replying to other questions, a visitor, Mr. Harrison, who had used it, said it would mean a clear gain of a penny for each shot, in doing without an explosive, if the apparatus fulfilled the same requirements as it had at the place he referred to.

Mr. TONGE: That is in addition to the gain from the quality of the coal brought down. Until they get fairly going we are prepared to get the coal down for a month for what it now costs for explosives.

Mr. HARRISON: It will make better round coal than gunpowder.

A number of invitations were then given to the inventors to try the apparatus in mines about Wigan and Manchester.

Mr. H. D. F. MATTHEWS suggested that the discussion be resumed at the next Wigan meeting.

The CHAIRMAN: You would then hear the results of the practical working of it. We are very much obliged to Mr. Tonge for his paper, and everyone wishes him success with his apparatus.

The discussion was then adjourned.

A Paper by Mr. Frederick G. Meacham, M.E., "On an Irruption of Coal into the 'Thick Coal' workings at Hamstead Colliery, South Staffordshire," in April, 1897, was postponed until the next Meeting, at Wigan.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XI. VOL. XXV. SESSION 1896-97.

The CONCLUDING MEETING of the Session was held on Tuesday, June 15th, 1897, at the Society's Rooms, Queen's Chambers, John Dalton Street.

The President: Mr. MARK STIRRUP, F.G.S., in the Chair.

NEW MEMBERS.

The following gentlemen were balloted for and duly elected Ordinary Members of the Society:—

Mr. GEORGE E. HARRIS, M.E., Assam Railway and Trading Co., Ltd., Margerhita, Assam, India.

Mr. ALEXANDER REID, Dover Collieries, Dover.

Mr. ISAIAH RICHARDSON, Manager, Blainscough Collieries, Coppull, Chorley.

Mr. JOHN JAMES WHITEHEAD, Bracklyn, Steven Street, Stretford, Manchester.

The PRESIDENT said that two or three other gentlemen had been proposed for membership, but the nominations arrived too late to be placed in the Circular, and would therefore have to lie over until the next meeting. These gentlemen would, however, receive any circulars which might be sent out to members in the meantime, and in fact would be treated on the footing of members.

Notice had been received from various gentlemen, of papers which they wished to bring before the Society. These must necessarily be postponed as this was the closing meeting of the present Session. One was by Mr. Greenwell, an ex-President, on the correlation of the Dover and Somersetshire coalfields, which would doubtless be of interest to many. Another was by Mr. Harris—who was one of their newly elected members—on the coalfields of Assam. That paper had been promised through Mr. Millington, another member. Mr. Humphrey had also expressed a wish to read a short paper on some special glacial deposits ; and Mr. G. H. Kinahan had been writing on the bog slides, or bog bursts in Ireland, on which there was some little discussion at a former meeting. It was a subject on which Mr. Kinahan might be supposed to be particularly well informed, having lived in the west of Ireland, and had special facilities for observation. These various papers would be read in the next session.

The President went on to say that his next duty would be to call upon Mr. Ward to read his promised paper on the rock salt deposits of Northwich. Mr. Ward, as they all knew, was a great authority on the salt deposits of Cheshire, upon which he had given them some very interesting papers at former meetings.

THE ROCK SALT DEPOSITS OF NORTHWICH, CHESHIRE, AND THE RESULTS OF THEIR EXPLOITATION.

By Mr. Thomas Ward, J.P., F.G.S.

PART I.

I think, in the presence of my old friend, Mr. Dickinson, I ought scarcely to stand here and speak of the salt deposits

of Cheshire, because, after all, whatever some of us on the spot may have tried to do, no one has investigated the subject more thoroughly than Mr. Dickinson. He presented two most admirable reports to the Government, which are referred to as standards and authorities at the present day; and any information you do not get out of Mr. Dickinson you will not find, I think, anywhere else. I do not propose to discuss the question so fully as Mr. Dickinson has done, but to deal simply with one small fraction of it—one that has attracted a great deal of attention of late years and that has caused more searching and more boring into the earth, in that district, than had taken place in all previous time. I refer to the great question of what is called subsidence, and compensation for subsidence. My friends, Professor Dawkins, Sir Leader Williams, Mr. Wells, and others in this room have likewise taken an active part in the investigation. I intend in this paper to deal especially with facts that have come out, and that enable us more clearly to define the limits of the salt beds in the Northwich district than has hitherto been possible. To get the exact figures which I shall lay before you has taken much time and labour. Some figures which had previously passed as gospel, when examined were found to be fallacious. I shall confine my attention, in the present paper, almost entirely to the upper bed of rock salt; and in a further paper, which I hope to present in the course of next Session, I shall be able to deal with the question at large, and will show you some interesting photographs.

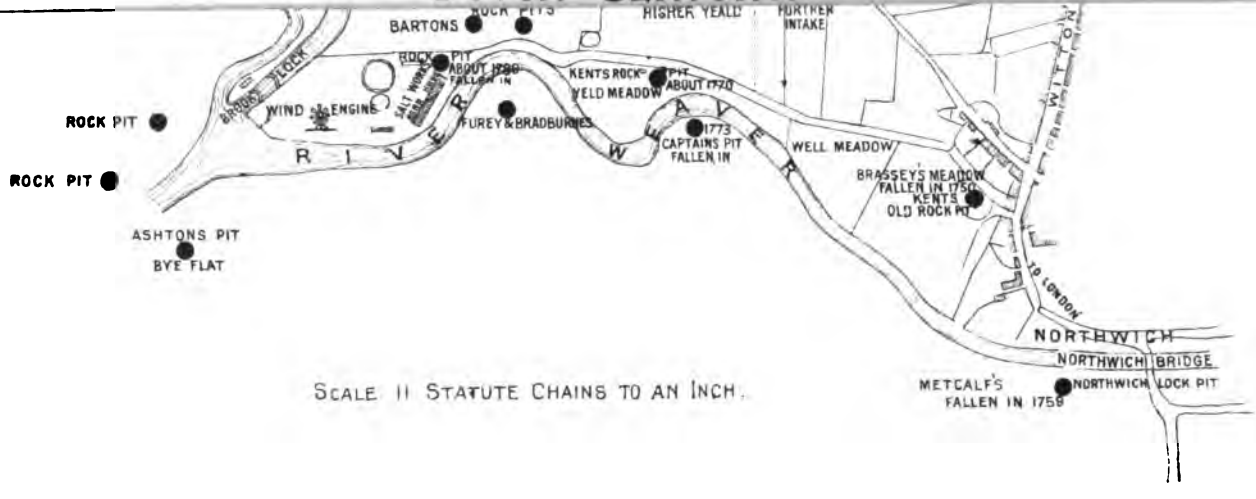
On December 12th, 1670, a letter was addressed to the Publisher of the Philosophical Transactions of the Royal Society by Mr. Adam Martindale, of Rotherton (Rostherne), concerning the discovery of a rock of natural salt in Cheshire. He says: "A gentleman of good account and reputation assures me that in our county there is lately

found out a great rarity, viz.: a rock of natural salt, from which issues a vigorous sharp brine beyond any of the springs made use of in our salt works, and this not nigh to any river or great brook, as all our salt springs in the county are." Mr. Martindale goes on to say that he thinks the information may be interesting to the Royal Society, and that if it is wished he will "view the place and enquire after the circumstances, and communicate them." He was asked to visit the place and report to the Society. He did this, and wrote as follows: "I am just now returned from visiting and viewing the salt works, and found things according to my friend's relation, only whereas I understood him that no running water came near it, I now perceive that he spoke of none that was considerable or none that might annoy it, for there runs near it, at least in the winter season, a small rindle or gutter rather, but it is wholly free from all danger of overflowing which threatens all other salt pits in this county every great shower through the vicinity of rivers." "The rock of salt, by the relation of the workmen, is between 33 and 34 yards distant from the surface of the earth, about 30 whereof are already digged, and they hope to be at the Flagg which covers the salt rock about three weeks hence. I doubt it will be several weeks before I can accommodate you with a parcel of it, that which the augur brought up being long since disposed of. The overseer hath promised to furnish me with a piece of the rock for your use. That piece of natural salt which the instrument brought up (divers saw it a pure ore) was as hard as alum and as pure. The first discoverer of it was one John Jackson, of Halton, about Lady Day last, as he was searching for coals on behalf of the Lord of the Soil (or Manor I should say), William Marbury, of Marbury, Esquire."

Trans. Man. Geol. Soc. Vol. XI. Vol. XII to illustrate Mr. Fox's Wards paper.

MAP SHOWING SITES OF MINES IN THE UPPER ROCK SALT

XVIII CENTURY.



This is the description of the first discovery of rock salt in England, and it was about a mile or so from Northwich. The mention of the "rindle" or "gutter" enables us to practically locate the discovery,—the more so as there are traces of an old mine on the spot, and evidence dating back to 1720 of the destruction of this mine about that date. Tradition says that the salt from this mine was fetched away by pack-horses, there being no navigable stream near till the Weaver was made navigable about 1730 under the Act obtained in 1721.

It is scarcely necessary to mention that the rock salt beds of Northwich, like all those in Cheshire, and probably all in the British Isles, are in the Keuper marls of the Triassic period. The method of formation of these beds I have pointed out in a paper on Rock Salt read before the Society in 1886. I do not propose to discuss at any length the formation of the salt beds in this paper, but rather to show the changes they have undergone in the past by the working of nature, and those they are now undergoing by the action of man.

The borehole put down by the Salt Union at Marston, near Northwich, in 1892, and carried to a depth of 2610 feet, was, after passing through the sands, gravels, and clays of the drift formation, entirely in the Trias. This borehole did not pass through the sandstones of the Triassic formation, but was abandoned, the prospect of finding coal at a workable depth being exceedingly small. The salt deposits were in the upper part of the boring, and no salt was found below 414 feet. The first 32 feet consisted of soil and drift, then 92 feet of Keuper marls, the remaining 290 feet consisted of rock salt and marls in the following order :—

	Ft.	In.
First bed of rock salt	90	6
Indurated marl with salt veins	27	11
Second bed of rock salt	91	9
Hard red and blue marl with salt	30	8
Rock salt	5	2
Hard red and blue marl with salt	8	2
Rock salt	12	6
Hard red and blue marl with salt	23	6
	290	2

It will be seen that there are two main beds of rock salt of about equal thickness. The deeper and thinner beds may be put out of consideration as neither by nature nor by man do they appear to have been affected after their deposit. Indeed, speaking generally, until quite recently, the same might be said it was thought, as far as nature was concerned, of the second main bed, known as the lower or bottom rock salt. As might be expected, the upper bed is the one that has been acted upon most by both nature and man, and the results of such action are plain to be seen.

When, owing to a change in the seasons, and a greater fall of rain, the salt lakes, at the bottom of which the beds of salt had been deposited, became fresh water lakes, nothing but mud or marl was deposited.

This must have continued for a long period, for no less than 92 feet in thickness of those marls overlie the salt at the point where the Marston borehole was put down. What the condition of things was when the change of climate took place it is difficult to say, but the upper bed of salt bears on its surface traces of erosion by water to a very great extent. There are furrows or miniature valleys over all parts of

the surface, and towards the edge of the deposit the salt seems to have been eaten away most rapidly. It would almost appear as if a stream of water had flowed close to the edge of the salt bed from east by south to north-west, as all along this course we find a rapid thinning off of the upper bed. One of the miniature valleys met with in a shaft sunk for brine had a north-west to south-east direction, and as this was well towards the middle of the upper bed, and the fall of the surface was to the south-east and south, no doubt the current of water fell into the stream about three-quarters of a mile away. Whenever any tunnelling on the surface of the upper bed has taken place, as has frequently been the case when seeking for brine, many of these ridges and furrows have been cut through. It is extremely difficult to arrive at any satisfactory conclusion owing to the complications introduced by the pumping of brine. The valleys on the surface of the salt may have been caused in geologic times long past, or may have been made quite recently. The miniature valley mentioned before as running from north-west to south-east was in a shaft sunk at Wincham, near Northwich, by Mr. Townshend. The shaft was 9ft. square. The upper bed of rock salt was quite dry, with the usual red and blue marls adhering quite closely to the salt. There was a difference of 2ft. 9in. between the highest point of the surface of the salt in the shaft and the lowest. Measured from the stage on which I was standing, the highest point was 4ft. 3in., the lowest 1ft. 6in. This was not the dip of the bed, as these salt beds have no proper dip, but was a water-worn furrow. The whole surface of the salt was dry. As the marl adhered very closely to the salt it would seem as if the furrow or valley had been made prior to the deposition of the marl overlying it, and consequently in Triassic times.

In 1895 I visited a shaft recently sunk in Marston about

half a mile to the N.N.E. of the one just mentioned. The level of the salt rock on the east side of the shaft was rather lower than that on the west, the same is the case in all the shafts to the east of the centre line from N. to S. passing through the Marston borehole.

The Marls immediately overlying the salt for from 6 to 12 inches were disintegrated by water. They were soft enough to be scooped out easily by the hand. Through this broken Marl brine was running in small streams. A tunnel was made from the bottom of the shaft for some distance. This tunnel was cut partly in the rock salt and partly in the overlying marls. It was practically on the top of the salt. The surface of the rock salt was very uneven and in several places channeled by water or weak brine. In one place the marls were very wet and the rock deeply furrowed. The tunnel cut across several furrows in which weak brine was found. The direction of these furrows was towards an adjacent shaft out of which brine had been pumped for a number of years. Wherever there were clear signs of water having passed over the salt and through the overlying marls the marls had lost all their tenacity and become crumbly. In this case no doubt the furrows had been to a great extent if not entirely caused by the pumping of brine in the adjacent shaft where the surface of the salt was rather lower, the shaft lying to the eastward of the tunnel.

From this brine shaft a tunnel was made a good many years ago in an easterly direction. The surface of the salt showed the usual gentle slope to the eastward and had quite a number of small ridges and furrows running across the tunnel in a northerly and southerly direction. To bring the brine from the furthest end of the tunnel to the shaft it was necessary to cut a channel rather over a foot in depth at the

Trans Man. Geo. Soc. Part XI Vol. XXV
to illustrate Mr. Thos Ward's paper.

NOR
SALT

ck Salt as proved is comprised
thin the Area Shaded

alt proved non existant in all Shafts
Borings along the Line marked ————
s made to the North except
n.

n at intervals of half a mile and represent
1 mile & 1½ miles from the Centre.

depths below ordnance Datum of First Salt found.

EAST

BARNTON

SHURLACH

SCALE :— 1½ INCHES = 1 MILE.

shaft and working out to nothing at the far end of the tunnel.

The marls overlying the rock salt, and through which the tunnel recently made was chiefly cut, were very interesting. They were a conglomeration of marl and gypsum. The gypsum was mixed up with the marl in a most curious way, being found in small quantities scattered up and down very irregularly. Here and there it was composed of spiky crystals fairly long, and occasionally of rather large crystals, but most generally the gypsum was non-crystalline. In several places a thin seam of gypsum ran vertically through the marls for several feet in height and could be traced on both sides of the tunnel. It seemed as if there had been a rift or crack in the marl and that the gypsum had filled it up. I found something similar in the marls brought up by the diamond boring tools from a depth of over 1700 feet. The gypsum formed a layer fully half an inch thick and nearly transparent. In one of the cores the marl had evidently a slight crack in it and the gypsum had filled it.

The limits of the upper bed of salt have been fairly well ascertained on all sides except to the north. The borehole put down at Marston appears to be on the highest proved portion of the salt bed. The salt was found at 47 feet below ordnance datum. Taking the borehole as a centre the surface of the salt seems to fall gently away in every direction. The furthest existing shaft to the east about half a mile away shows the rock salt to lie a little over 65 feet below ordnance datum or a fall of 36 feet to the mile. A little to the north of this shaft three borings have been made for brine, two of these show the salt to be 95 feet below ordnance datum whilst the third not a hundred yards further away to the north found neither salt nor brine before 170 feet below ordnance datum. As the bottom of the first bed

of salt has never been proved in any portion of the Northwich district lower than from 140 to 150 feet below ordnance datum it is clear the upper bed does not exist at this boring, and if salt was found at all it must be the lower bed. There is evidently a rapid thinning off of the salt in this direction.

To the south-east of the Marston borehole at the distance of about a mile a borehole was put down to 354 feet from the surface or nearly 280 feet below ordnance datum and no salt found. From this point proceeding by south to west a series of shafts and borings ranging from a mile to nearly a mile and a half from the Marston borehole have been sunk and bored and in no case to the east of a north and south line passing through the Marston borehole has the upper bed of salt been found at a distance of over one mile. All the existing shafts within the one mile radius show a gradual thinning out of the upper bed or fall of the surface. Several boreholes and a shaft have been sunk on the chemical works of Bowman, Thompson & Co., a little over a mile in a south easterly direction from the Marston borehole and in none was the upper bed of salt found though the lower bed was proved. About six or seven years since a boring was made in a triangular plot of land a little to the west of the Northwich station. The cores were all brought up and no salt was found till the depth of 240 feet was reached this was proved by continuing the boring down to 502 feet to be the second bed of salt. The nearest existing shaft to this borehole, viz., Neumann's which is about 400 yards to the N.N.W. showed the upper bed to be rapidly thinning out there being a fall from 67 feet below ordnance datum at the Penny's Lane Mine less than 100 yards to the north to 90 feet at Neumanns. The upper bed which is 90 feet thick at the Marston borehole is only 30 feet thick at Neumanns. About a quarter of a mile further to the west in the Dane

Meadows about a mile and a quarter to the S.S.W. of the Marston borehole a shaft was sunk a distance down and continued by a borehole to 210 feet from the surface which at this point would be below the bottom of the upper bed of salt and no salt was found only weak brine. About 32 years ago Mr. John Thompson a great authority on the shafts, mines and salt of the Cheshire district in a correspondence with me wrote. "The thickness of the upper bed of rock salt is about 25 yards, but this thickness is only maintained within a circle of about three miles in circumference, outside of which it thins off rapidly on the upper surface. I have proved a thinning off of about eight yards within a distance of about 200 yards. The thickness of the upper bed being 17 yards only in Mr. Hadfield's mine. A more remarkable instance however occurs in the town of Northwich. In sinking for brine for Mr. Marshall in the Cotton Works Yard the Rock Salt was found at the usual depth 36 yards from the surface (or about 64 feet below ordnance datum)."

"In the yard now converted into a cattle market, the distance from the brine shaft being about 150 yards only, we bored down to a depth that would not only have reached the rock, but more than would have passed clean through the bed, and that without finding the usual clays or metal which indicate the presence of rock salt."

The mine referred to as Hadfield's by Mr. Thompson is the Penny's Lane Mine mentioned before. The boring in the Cattle Market where no salt was found was on the north bank of the river Dane, in close proximity to the old "Sheath" or brine shaft mentioned in all the early histories. I have been told by an old man that the borehole was put down at the bottom of this old shaft. The place is about 500 yards to the north-west of the borehole in the Dane

Meadows, and about a mile and a quarter from the Marston borehole.

Still further to the west (about 500 yards) a borehole was put down in Leftwich in Pimlott's boiler yard near the banks of the river Weaver. The borehole was carried down 334 feet, and although brine was met with yet there were no certain indications of rock salt. This borehole was carried down to fully 290 feet below ordnance datum. About 600 yards due south of Pimlott's borehole and a mile and three quarters to the south-west of the Marston borehole, shafts and boreholes were put down on the Riversdale estate. Salt was struck at a depth of 225 feet, and was 10 feet thick; at a depth of 289 feet another bed of salt was proved, and some brine was found. The first salt was 180 feet below ordnance datum, and could not have anything to do with the upper rock salt, as the bottom of that bed is nowhere lower than about 140 to 150 feet below ordnance datum. It is extremely difficult to correlate the rock salt at Riversdale with any of the rock salt in the Northwich district. It seems quite certain that it does not belong to the upper bed.

The next shaft to the north-west of the borehole in the Dane Meadows, and almost in a direct line from this borehole through the one in the Cattle Yard near the Dane, is the Winnington Salt Company's shaft rather more than 1¼ miles to the south-west by west of the Marston borehole. This shaft was sunk 84 yards, and no rock salt found, though carried fully as deep as the bottom of the upper bed.

Nearly direct north of this shaft and about a quarter of a mile away, and rather less than a mile and a quarter from the Marston borehole, are two shafts of Brunner, Mond and Co. In these shafts rock salt was proved at 112 feet below ordnance datum. If this is the upper bed it must have thinned out very much. However, after a careful com-

parison of the figures of the nearest shafts, viz., the Baron's Quay, Witton Hall, and Neumanns, I am compelled to acknowledge that I am puzzled. The depths to the bottom of the first bed of salt in these mines are:—

	Below Ordnance Datum.
Baron's Quay..	113
Relief Shaft, Baron's Quay	117
Neumann's, Witton Mine	120
Penny's Lane, „ „	120

These mines all lie in a south-east direction from Brunner, Mond's Winnington Shafts. The figures would show that the salt met with in these latter shafts cannot be the upper salt, the difficulty then comes in that if it is the lower the customary 25 to 30 feet of marls lying between the salt beds must be missing. A borehole was put down to a depth of 203 feet below ordnance datum, and this was reported as the bottom of the top bed of salt. At the Marston borehole the top of the lower bed of salt was 171 feet below ordnance datum, or 32 feet higher than this, besides the 30 feet of intervening marl, and this is the lowest in the district. It may be possible that as this Winnington Shaft is near the edge of the salt, the beds may have all thinned out, and in the 91 feet from the surface of the salt to the bottom there may be a thin section of the top bed, also thin marls and a thin bottom bed. In the diamond drilled borehole near the Northwich Station, the bottom bed of salt was only 60 feet thick, and in the boreholes on the chemical works of Bowman, Thompson and Co. the lower salt bed was proved to be rapidly thinning off to the eastward and south, reported two inches to the foot in one case, and three feet six inches in 40 yards along a tunnel in another case. From the Winnington Shaft, and at a distance of from half to two-thirds of a mile, and about one and a quarter miles

from the Marston borehole, and a short distance from the river Weaver, there is a group of four shafts, in none of which has rock salt been found, but all have brine. They have been sunk to the depths of 128 feet, 137 feet, and 130 feet below ordnance datum. A short distance (about 100 yards) further to the west a shaft was sunk, and no rock salt whatever found till a depth of 169 feet below ordnance datum was reached, which is the depth of the lower bed. The shaft itself only touched the salt on the east side even then. Two boreholes, the one at Gunner's Clough, Barnton, and the other at the Poultry Yard, Winnington, from a quarter to half a mile further west, have been put down deep enough to have passed through both salt beds if there, but no trace of either salt or brine was found.

The British Brine Shaft at Anderton, one of the four just mentioned, is the most northerly of the group, and to the west, north-west, and north of this there have been neither shafts nor boreholes. The Marbury brine shaft is nearly on the line between the British brine shaft and Marston Hall mine, but rather to the south, and on the direct line between the Marston borehole and the British brine shaft, and about three-quarters of a mile from the borehole. The rock salt is here 94 feet below ordnance datum.

At the distance of about a mile to the north-east from the British brine shaft at Anderton, is the Marston Hall mine shaft. This is the most northerly shaft in the Northwich district, and is about half a mile to the N.N.W. of the Marston borehole. The top rock salt is here met with about 56 feet below ordnance datum. As the Pool Pit and the Marston Old Mine have rock salt at the same level and lie between the Marston borehole and the Marston Hall mine it would seem as if there was not much fall of the salt on the north of the borehole. Taking the line of shafts furthest

to the north and extending from the Marston Hall on the west to the Alexandra brine shaft on the east, a distance of nearly a mile, and all within or close to half a mile from the Marston borehole the upper rock salt is met with at

56ft. below ordnance datum.	55ft. below ordnance datum.
56ft. „ „ „	55ft. „ „ „
56ft. „ „ „	60ft. „ „ „

The two shafts with 55 feet below ordnance datum are the nearest the borehole, whilst 60 below ordnance datum is the furthest to the east.

From the figures and explanations given it has not been difficult to fix very nearly the limits of the upper bed of rock salt to the east, south, and west, whilst to the north from lack of shafts or boreholes no such limit can be marked out. There are surface indications which prove that the salt extends nearly if not quite to Pickmere, and probably to Marbury Mere.

The level of the bottom of the upper bed of salt though not quite regular is more so than that of the top. The greatest thickness of salt and lowest levels are in the immediate neighbourhood of the Marston Coal borehole. From the following table it will be seen that the depth of the bottom of the first salt bed below ordnance datum does not vary as the thickness of the salt varies, so that consequently the surface of the salt bed must exhibit the greatest variations.

	Thickness of bed. Feet.		Bottom below O.D. Feet.
Borehole	90	....	138
Albert	93	....	141
Crystal	89	....	138
Neumann's, Marston	88	....	143
Pool Pit	85	....	141
Adelaide Mine	84	....	138

	Thickness of bed. Feet.		Bottom below O.D. Feet.
Worthington's Brine....	78	....	139
Amalgamated	72	....	137
Witton Hall	71	....	128
Marston Hall.....	66	....	122
Baron's Quay	63	....	114
Penny's Lane	51	....	120
Neumann's, Witton	30	....	121

Between the Upper and Lower Main beds of salt there is a stratum of about 30 feet in thickness of red and blue salt marls common to the salt district. In this marl there are veins of pinky coloured rock salt, not lying parallel with the beds of salt, but running chiefly vertically. In examining them it would seem as if this marl had been deposited in the wet season of the year in a slightly brackish salt lake, and that in the hot and dry season when the waters of the lake shrank the mud became exposed to the sun and shrank and cracked. In these cracks or crevices, which seem to have been extensive, the now concentrated waters of the lake found their way and formed the veins of salt that are so characteristic of this layer of marl. The thickness of the bed does not vary much, as will be seen from this table.

	Feet.		Feet.
Borehole	28	Amalgamated	30
Albert	28	Witton Hall	27
Crystal	29	Marston Hall	28
Neumann's	29	Baron's Quay	30
Pool Pit	27	Penny's Lane	30
Adelaide..	26	Neumann's (Witton)..	30
Worthington's	30		

This marl, although locally called "stone" from its great hardness soon becomes soft and crumbles away if exposed to water.

It is extremely difficult to tell what period of time passed whilst this 30 feet of marl was being deposited. However long or short it may have been, the change in the climate was not exactly sudden, for the salt beds, overlying and underlying, both contain a good deal of marl. The proportion of marl contained in the salt beds is a fair criterion of the wetness or dryness of the seasons. Where the salt is fairly pure and but little marl, the seasons were characterised by dryness. Where the marl preponderates wetness must have prevailed. Nothing so clearly proves that rock salt is a crystallised deposit in water as the marl or mud mixed up with it.

The rock salt mines in the upper bed were all situated alongside the River Weaver or the Witton Brook, or else alongside the roads leading to these streams. This is the reason, as will be seen later on why the great subsidences that mark the Northwich district occur alongside these streams and roads. Although white salt had been made from brine, probably as far back as the times of the Romans, yet when the River Weaver was made navigable under the Act of 1721, more rock salt was sent down than white salt. In 1732, the first year after the navigation was completed, 9,322 tons of rock salt were sent down the river, probably for export to Ireland and Denmark. In 1747 this had only increased to 13,310 tons. In 1764 it reached 30,141 tons, and in 1777 to 54,176 tons. It was about this time that many pits were sunk, but most of them were soon drowned out by water or weak brine, locally called "Roaring Meg." The shipment of rock salt down the Weaver continued at from 50,000 to 60,000 tons annually till the end of the century. In 1781 the second or lower bed of rock salt was discovered in the Northwich district, it having been found two years earlier at Lawton, in the south of Cheshire. The salt in a portion of this bed being found purer, the mines in

the upper bed were abandoned and very few were worked far into the present century. Only one of these mines, the old Marston mine, now remains, and it is the one in which the boring was made by Mr. Gilbert, the Agent of the Duke of Bridgewater, when he found the lower bed of salt. The Marston lower mine was probably the first mine in the bottom rock salt in Cheshire.

The history of the old top mines is very interesting, especially in connection with the large lakes or "flashes" that have been formed over many of them. The mine the furthest to the south and the most southerly point at which the top rock salt has been proved, was one near to the old Northwich lock, a short distance to the north of the Town Bridge, on the left bank of the Weaver. This fell in in April, 1759. Nearly opposite to this mine, but in Witton, on the right bank of the Weaver, was a mine that "fell in" about 1750. The old rock pit hole caused by this falling in was filled with rubble and rubbish some twenty or thirty years ago. Proceeding along both banks of the river Weaver we meet with old mines. On the left bank were the Captain's Pit, which "fell in" in 1773, and Furey and Bradburnes also destroyed. Over these two mines and one at the Bye-flat corner of the river a large "flash" or lake formed. This is now filled up by waste from the alkali works of Brunner, Mond & Co. On the right bank of the river as far as the Witton Brook a number of mines were sunk but not much worked owing to the water getting in and destroying them. There is a curious note on an old map of this district which tells the state of the strata overlying the salt, it is as follows: "In the Further Intake about the year 1776, Mr. Roylance attempted to sink for rock, but was stopped at the depth of 23 yards by a very great body of putrid water, to which the labourers employed in these works from the frequency of meeting with it gave

to it the name of 'Roaring Megg.' By this water many persons have been stopped in sinking both in Witton and Winnington." In 1750 a Mr. Page had been stopped in sinking two shafts in lands adjacent by this same "Roaring Megg." Another note says that "about 1763 Mr. Kendal sunk a rock salt pit, but being wearied with it he assigned it over to Mr. Kent, who at very great expense completed it and got some rock salt out of it, but in a little time was driven out by the above mentioned water." On the site of the present Island Salt Works another rock salt mine fell in or was drowned out by brine from two adjacent rock salt pits destroyed shortly before. On both sides of the Witton Brook, which was made navigable shortly after the River Weaver, viz, about 1758, a number of mines were sunk and also brine shafts. None of the mines lasted long. A note on the old maps says: "In the Heywood, in the holding of Mr. Marshall, a rock pit was sunk, and a very great quantity of rock salt got out of it. In the year 1783 water from the adjacent fallen rock pit in the lands of Mr. Jervis broke in and filled it up." There are records of a considerable number of other mines and shafts in close proximity to the brook. At Witton Mill Bridge over this brook a mine fell in in 1757, and near Anderton, close by the junction of the Witton Brook and the River Weaver "a rock pit had fallen in" just prior to 1765. The Witton Bridge was at the end of the navigable stream, but a number of rock salt mines were sunk along both sides of the main road to Warrington, which crosses this bridge, and alongside the Dunkirk Road, and another one leading to Marbury.

The whole of these latter mines being on high land and not in the meadows along the stream, when they fell in, as they eventually did, were not submerged so as to cause a large "flash," but formed holes which filled with water. These are known locally as "rock pit holes" and form a

prominent feature in the Dunkirk district of Witton, and in the adjacent parts of Wincham and Marston. Along the road to Marston Forge, which road passes the site of the first pit recorded to have been sunk, and terminates close to the only existing top mine, there are several old rock pit holes, and on a map of 1786 there are some interesting notes which, if put on record, may be useful, and will show how common was the destruction of these old mines by water. The notes are as follows :—" An account of the several rock salt pits belonging to and sunk in the lands of Sir John Fleming Leicester, Bart., in Marston, taken in the year 1786 At letter A a rock pit was sunk by Henry Warriner in the year 1771, which was worked about three years and then filled with water, which affected the pit at letter B. At letter B a rock pit was sunk by Messrs. Pownall and Beckett in the year 1772, which is now (1786) continued in work. At letter C a rock pit was sunk by John Stubbs in the year 1773, and now is worked (1786) ; these three are too near together, the failure of Warriners' endangered the other two, and should any other pit be sunk in the adjacent land the failure of one may destroy the whole." These have all been destroyed nearly a century. The following note was added shortly afterwards, and as it refers to a mine now totally submerged, which was one of the earliest sunk to the bottom rock, and of which I possess a plan showing the method of working the mine shortly after this date, and the thickness of the salt worked as well as the method of the pillaring, it may be useful to record :—" At letter D a rock pit sunk in spring 1787 by Messrs. Meyer and Wilckens, of Liverpool, and a great quantity of rock salt is here got." This mine was sunk in the Crabtree Croft, a field near the junction of the roads from Marston and Wincham, now covered by what is locally known as Neumann's or the Marston Flash. Alongside the Dunkirk

Road, which joins the Warrington Road from the eastward, near the Witton Mill Bridge, are a number of rock pit holes showing where the old top mines existed Some of these had fallen in prior to 1770, and Ashton's that fell in in October, 1838, caused a serious loss of life. The Dunkirk district has the largest number of old rock pit holes filled with water, and has now to a large extent become submerged.

In working many of the mines in the upper bed of salt, only one shaft was usually sunk but this was a sump shaft. For instance a shaft was sunk part way down to the rock salt, this was called the day shaft, then a tunnel was driven at right angles in the marls for a short distance and a second shaft called the sump sunk at the end of this tunnel to the rock salt. The salt was raised by a windlass to the tunnel, then conveyed along the tunnel to the first shaft and finally wound up to the top by a gin worked by a horse. The day shaft was generally called the gin shaft. The sump shaft was sunk in many cases nearly to the bottom of the salt bed, this depth varied according to the quality of the salt. As soon as the shaft reached the sole of the intended mine a cavity was worked out and the pillars to be left were marked out. In an old sketch of Bancroft's mine, now under water, which was set out and worked evidently on a systematic plan a circle of 10 yards in diameter was worked out, the centre being the centre of the sump shaft. At regular intervals on the circumference of this circle four pillars were set out—the face of the pillar being three yards, the side six yards and the back six yards. About six or seven yards in the rear of these pillars and on the circumference of another circle four more pillars were set out, of the same size as the first four, but opposite the openings between the first pillars. In the rear of the second pillars and about the same distance away a third row of four pillars

on the circumference of another circle was set out opposite the openings between those of the second row and in a line with the pillars of the first row. These were four yards on the face, seven on the side and seven at the back. A fourth row still further back and still consisting of four pillars to be of the same size as those of the third row and similarly situated had been set out and partly completed when the plan was made. There is no indication of the depth of the mine from the sole to roof so the height of these pillars is not known.

Having since the foregoing was written visited the only existing upper mine I am able to describe the method of working more accurately. This mine was abandoned towards the end of last century shortly after the lower mine was sunk. The shaft to both the upper and lower mine is what is called a "two tub shaft," the only one we have now working. The approach to the upper mine is through an opening in the side of the shaft about the size of a large doorway. The pillaring of the mine corresponds almost entirely with that of Bancroft's except that the pillars in the first circle round the shaft are four yards on the face, and about seven yards along the side. On one side of the shaft a pillar had not been cut through behind. This may have been because the present shaft is not the old shaft to the top mine. The second row of pillars were placed opposite the openings of the first row, and six or seven yards in the rear. These were about four yards by seven yards. The mine seemed to form at the furthest points from the shaft, a series of chambers in process of being worked out, the pillars forming side walls. As soon as the pillars were the right size the chamber was cut through behind them and the pillars left. They were all more than 30 feet in height, probably nearly 35 feet. The pick work of the miner was very carefull y done and the roof and sides,

where left permanently, were dressed down. The roof of the mine in all the chambers had the appearance of the ceiling of a room with a series of pentagonal and pear-shaped designs, some of them looking as regular as a pannelled ceiling. These markings are in the salt and not caused by the pick. There were no signs of cracking or splitting anywhere except in one pillar and that not recent. The water is very carefully collected into water pits and reservoirs, and very little escapes upon the sole of the mine.

This system of pillaring was not followed out in all the mines. From an old plan in my possession it would seem as if long walls of rock salt were left at times and the salt was got in what might be called streets leading to the shafts. As the mines became nearly worked out the proprietors cut through these long walls and took away much of the salt, leaving pillars of no great strength. These crushed and let the roof down and the water got into the pit. The shafts being the weakest places the water got down them first, and not being saturated brine as soon as it reached the sole of the pit it ate away the foundations of the shaft pillars, and in a little time these collapsed and a conical hole widening out to the surface was formed. The clays and marls formed a puddle, and by degrees the the hole became filled with water and formed what is locally called a "rock pit hole."

There can be no doubt but that the pillars originally left to support the roof were not always strong enough. There have been cases in the lower mines where this has been so. However, the process of "creep and crush" in these lower mines is a slow one. The corners of the pillars give way first and pieces of rock salt fly off and fall to the sole of the mine. As the pillar decreases in strength larger pieces split

off and the upper portion is broken completely down. The roof gradually follows the crushing pillar. As the sinking does not take place evenly all over the mine, but most frequently at the furthest distance from the sides of the mine and generally near the shafts, the roof curves down from the sides towards the sinking centre, and the salt cracks and forms V-shaped openings. As the salt was occasionally mined through to the marls in the roof, especially where the surface of the salt was irregular, water entered and could not be kept out. This, by dissolving the bases of the pillars, caused a collapse and the mine "fell in." The upper rock salt being mined deep the pillars were lofty and consequently weak for their size, and the cavity of the mine was so great that the roof could not creep down to the sole without causing a complete rupture of the overlying salt and marls. In the lower mine the roof crept (without very serious rifts) as much as eight or nine feet. In one case I could just walk in the lower mine, my head touching the roof. The original height had been 15 or 16 feet. A few years ago the water came through the rifts in the thick overlying salt and marls and destroyed this mine. The roof had been creeping for over 30 years. There are two distinct causes for the collapse of the mines in the upper rock salt, viz., insufficient pillaring or pillars not strong enough, and the influx of water. The two combined have produced the extensive sinkings which characterise some portions of the Northwich salt area. Water is by far the more rapid and destructive of the two. Nothing acts so injuriously on the salt as water, and the whole of the most extensive sinkings in the district have been caused by water entirely, but have been intensified where old mines existed.

It may be interesting to put on record a note on an old survey made in 1789 of a "field wherein is a rock pit, with

buildings and gardens in Witton cum Twambrook." These are entitled "Remarks," and read thus:—"Area of each pillar in the rock pit is 23½ yards. The contents of the whole 32 pillars is 11¾ perches.

Depth of the day shaft is 41⅓ yards.
" " metal below that is 8¾ yards.
And depth of the hollow 11¾ yards."

This note is the more interesting as it refers to the Ashton mine which fell in in October, 1838, taking down and burying twelve men, of whom five were killed. The description given at the time was to the effect that "for some time previous this upper mine was considered insecure, from the pillars left to support the superincumbent earth being in a tottering state, and the men had discontinued their work," this means in the lower mine. It would seem that the men were at work on the surface amongst the buildings and about the shaft. As very little water got into the bottom mine at the time through the falling in of the top mine, it is evident that the collapse was owing to the crushing of the pillars. From the figures given above it would seem that the pillars were about six yards by four yards, not more, and that they were 35 feet high. The mine was not a very large one, and it would seem as if 32 pillars should have been enough. They were evidently too small. It is quite possible that the bottom mine had its pillars too weak, and that, as in the neighbouring mine, the roof had begun to creep—if so, this would take away the support from under the pillars in the top mine.

The whole surface of the upper bed of salt has been exposed to the action of water in Triassic times, and has become worn away almost to the shape of an open umbrella,

or of some of the large fluted or corrugated shells which we see occasionally. This fluting or channeling was the work of nature. During the last century or so man has not only mined the salt, and by weak pillaring and letting in the water caused the surface of the land to collapse, but by excessive pumping of brine has caused a far more extensive channeling of the surface than was caused in Triassic times. As far as can be judged from the appearances, it would seem as if, owing to some cause difficult to explain, the surface of the upper bed of salt became exposed to the weather. There are instances in Spain and in the Salt Range of India, and many other places, where the salt bed has become elevated considerably above the surface of the land and forms part of a range of hills. Where the salt thus elevated is exposed to the rain it is eaten away and furrowed either on the surface or the sides; in some places, as in India in the Kohat rock salt district, a regular valley has been formed, and the salt forms low hills on both sides, having the salt exposed and eroded. In Cheshire it would seem as if instead of the beds of salt being elevated, and so exposed to the weather, they gradually sank, and finally became deeply covered with mud. It seems impossible for the salt to have been extensively deposited in a very deep lake as the crystals do not form till the water becomes saturated brine. It is only in the hot dry season when evaporation goes on at a rapid rate, and the lake becomes comparatively shallow that the salt forms. When salt crystals are exposed to the air they become covered with a white efflorescence, but there are no signs of this in the rock salt, probably the fresh water dissolved it. It may be possible that the rising of the hills surrounding Cheshire caused a slight dip of the salt beds and that the water drained towards that part of the district where no salt beds exist, as to the south-east, east, and north-east of the Northwich district.

Mr. Joseph Dickinson moved a vote of thanks to Mr. Ward, a gentleman, he said, who had had unusual opportunities of observing all the changes and developments in the salt districts of Cheshire. The details given in the paper must have convinced members that Mr. Ward had all the facts at his finger ends'.

Professor Boyd Dawkins, in seconding the motion, said it was a great satisfaction to him to be present and to hear Mr. Ward again place the Society under obligation to him. He had already given them two most admirable papers on the salt question, and the present one, they might hope, was the first instalment of a work which would occupy many of their afternoons, so that all Mr. Ward knew might be placed on record for the interest of posterity.

The vote of thanks was passed unanimously.

Mr. Ward said: I am extremely obliged to the members for their vote of thanks. It always gives me pleasure when I can at any time add to the information of the Society on this particular subject. It is a subject on which there is a good deal to learn; it is one that has given rise to a good deal of discussion, and I think almost every geologist of note has dealt with it of late years.

The President said: we have several gentlemen present who are known to take a very deep interest in the salt deposits of Cheshire—Sir Leader Williams, Mr. Wells, Professor Boyd Dawkins, and Mr. Dickinson—gentlemen all well acquainted with the subject; and I shall be glad to hear their views upon any of the points that have been brought forward by Mr. Ward. As we have heard, this is the first instalment of what I am sure will prove an important contribution to our Transactions, and it will be of great value to those who may have occasion to seek information as to

the present and past physical aspects of the salt districts of Cheshire.

Mr. Dickinson said: Mr. Ward has gone so much into detail that the difficulty is to know what point to begin at. He has given us the positions of nearly all the shafts that are known, and the explorations—the depths below ordnance datum, and so on—and he has also given an account of the mode in which the salt mines have been worked, and how the top mines gave way consequent, as he put it, chiefly on insufficient pillaring. But he may have noticed that there was another cause besides insufficient pillaring for the top mines giving way, and that was the leaving an insufficient roof to form beams across the pillars, and sometimes also from the mode in which the mines were worked, the beam being in some cases actually cut through. These being near the surface it is not surprising that the streams found their way into the mines. Another thing Mr. Ward mentioned was the beautiful way in which they dressed off the roofs of the mines in olden times. They were dressed off as finely as the ceiling of any room, and showed the structure of the salt. There is not now the same attention given to the dressing off of the roofs of rock salt mines. The rock is blasted with gunpowder and the roof left very rough. This should in the early working of a mine—say in the roofing about six feet high—be carefully dressed off, because when once the benching is removed there is scarcely any access to it unless it be by a long ladder. Mr. Ward mentioned 35 or 36 feet as the depth of the workings in some of the mines—some of them more—but in the lower beds they have not yet worked to such a thickness, seldom more than 18 feet. Now I think, in Ireland, they are taking a considerable lead in that respect. At the commencement they began to work from 35 to 40 feet in height, but they have increased that considerably and are getting on to 60

or 70 feet; so that, as you may see, there are many points that require very careful attention, particularly as to the roof. I might go on talking about these matters for an hour, but there is no necessity, as we shall have Mr. Ward's paper printed in the Transactions.

Mr. GERRARD said: Mr. Dickinson has touched upon one point upon which I would like to ask Mr. Ward a question; that is, as to the amount of rock salt left—at the top, up to the marl—if he has found, in his researches what development or what change has taken place under that head—how much rock salt was formerly left and what has been considered to be the best thickness, or the amount, of rock salt to leave up to the marl. That was one of the practical points which occurred to me in hearing this most valuable and interesting paper read.

Sir E. LEADER WILLIAMS said: We have had from Mr. Ward what appears to me to be a most valuable statistical paper, and I hope when it is printed we shall have the maps given to us also for the Transactions. With these we shall have a mass of detail which can only be got together in a life time by one who has been on the spot and has worked as hard as Mr. Ward. It will be the authoritative source for all facts and data about the salt mines of Cheshire. There is nothing like it in any transactions I know of. Mr. Ward referred to the manufacture of salt in remote times. On the banks of the Weaver, near Northwich, I was fortunate enough, many years ago, to discover some lead pans about six feet square, which were undoubtedly Roman. They are now, I believe, in the Warrington Museum. There were also some of the old wooden scoops they used. It is a singular thing that since that remote time we should have gone on manufacturing salt by evaporation in exactly the same way. Our pans no doubt

are larger, but the process is the same. There is a very interesting section on the wall; it shows the great amount of erosion which goes on; and we had a wonderful instance, a few years ago, of the great amount of space occupied by water in the rock mines, and also in places where the brine has eaten away the salt and it has been taken up by the pumps. Near the Weaver, at Witton Brook, one of these subsidences took place, and you may judge of the space it filled underground, when the water got in, for the river instead of flowing down to the sea sank into the interior of the earth, and this went on for a considerable length of time. I cannot tax my memory with the particulars at this moment, but I read a paper, in which all the details were given, before the Institute of Civil Engineers. No doubt Mr. Ward has all the records taken at the time. The brine rose in the shafts at different points, at a considerable distance from the scene of the actual subsidence. There is a mass of interesting facts connected with the salt manufacture, and when Mr. Ward has given us the remainder of his paper we may have a good afternoon's discussion upon it.

Mr. Wells said: I was Engineer of the Weaver at the time the mine fell in to which Sir Leader Williams has referred; and it may interest you to have a little detailed account. The ponded area of the Weaver in connection with that mine I should say was about 70 acres, and the area draining into it 300 square miles or upwards. The mines took in the whole of the water flowing naturally off the ground, in the month of December, and they lowered the 70 acres of the pond ten inches. That is a true measurement, for I had the gauge examined, and will give some idea of what the cavities must have been. With reference to the height of the mines, perhaps Mr. Ward will tell us whether they were not usually, if not always, taken to the full depth of the rock salt that was worth

getting. I have always supposed such was the case, and was very much struck two or three years ago, when inspecting some salt mines in Germany, to find the extraordinary advantage they appeared to have over us, for I stood in a chamber which I was told was 160 feet in height, formed in rock salt of excellent quality, that then there was a floor 16 feet thick, and above that was another chamber 160 feet in height; so that there had been 336 feet of good rock salt in that particular mine. The enterprise of Englishmen, in supplying so much of the world with salt, as was done for so many years, has struck me forcibly since I saw the enormous depths of the salt in Germany. Mr. Ward has alluded to the difference of the upper and lower beds of rock salt, and also to certain mines, as to which there is some doubt whether they belong to the upper or the lower bed. It has been told me, and accepted by me and by others—but Mr. Ward, who is on the spot, may have even more accurate information—that in the borings at Riversdale on a certain occasion the water suddenly rose to within a few feet of the surface; that, following upon that, the shaft at Winnington filled with brine, and beyond that again the shafts at Anderton were affected. There appeared to be a connection between these mines, whether they belonged to the upper or the lower bed. At a different time, mines in another part of the town, that were certainly in the upper bed, became flooded; the influence of that inrush was felt at Winnington, at Anderton, and in part of Marston. In one of these inrushes a certain group of mines were effected; at another, another group of mines; and on each occasion there were certain mines affected in each group, although it did not affect the whole of them on either occasion. If Mr. Ward can give us more information on that point it will, I am sure, be most interesting.

Mr. Atkinson said: The paper which we have had from Mr. Ward will be of the greatest value and interest. There was one point that struck me in connection with those old mines, that is the risk there may be of new mines, at some future time, holing into the old workings. I suppose in the case of many of them there are no plans in existence, and in other cases the plans may not be available to people to whom they would be useful. Any information of that nature would be very useful, if put on record, to assist people who may have to work the salt in future.

Mr. Ward, in his reply upon the discussion, said: I did refer to the matter of working through the roof at times, that was one of the causes I mentioned—that in working they sometimes came across the deep valleys and cut into the marl through the salt. That certainly was a cause frequently of the water getting into the mines and destroying them. The simple answer to the question as to how much rock salt they got out of a mine is—how much is worth getting out? There is plenty of salt, but it is not all worth getting; there is too much marl in it. If we get 18 or 20 feet now, the upper four or five feet we scarcely know what to do with; it contains a very much larger per centage of marl than the others, and is not so commercially valuable. It can only be used for certain purposes. In Germany, where they have a pure rock salt, they may mine nearly the whole. When English rock salt was almost the only rock salt to be had they did not turn up their noses at it. Now, to compete with the Germans, the utmost care is needed. They put their salt on every market, and our English rock salt is scarcely worth anything. The reason why 15 feet or 18 feet only out of the 90 feet is got is because 15 to 18 feet only is a mercantile article. Till a few years ago the roof, or impure rock, was left in the mine, but there came a time when it was discovered that, after you had extracted the

sulphur from the pyrites, copper was left, and this could be recovered. The works were set up for extracting the copper from the burnt ore, and large quantities of the rough rock—for which we were glad to get one shilling a ton—went to them. Now, unfortunately, they turn up their noses at that, and will have nothing but the best rock. As to the supports left, unfortunately, in the early days the miners thought that if they left any pillars at all the roof would stand, and half the bottom mines were ruined through the pillars being too small. Now the pillars, instead of being only five or six yards square, are 10, 12, 14, and some even 20 yards; and even now pillars are giving way owing to not being strong enough. But there was no criterion; as long as salt was worth getting they got it, and it was that that led to many of the mines falling in or getting waterlogged. Sir Leader Williams referred to the old salt pan that was discovered in the course of some excavations at Northwich. It was for some time in the Warrington Museum, but is now exhibited at Earl's Court, London. Sir Leader also referred to the Platt's Hill Pit. There were really no accurate maps of the whole of the mines, so that, in mining alongside disused workings there was great risk of a shot bursting through the wall and letting in the brine. Accidents of this kind actually happened, and some workable mines were flooded. Mr. Wells asked a question about Riversdale. I do not know that I can answer it very accurately, because there are a good many difficulties in the way. You cannot always tell why (when there is an inburst of water which raises your shafts 60 to 100 feet in a night) certain shafts are affected and others not; but I am inclined, myself, to think that there is a ridge or saddle (running in a direction pointed out on the map) which has something to do with it. Unfortunately we cannot tell what is below in this district because this is the part where the mines have all fallen in;

and from that letter of Martindale's the rock salt must have been very near the surface. As to the old maps, I dare say I have as large a collection as anyone. We have been collecting, and are preserving all the maps we can get of the bottom mines. We have not the whole of them, but we know fairly well now where the boundary lines are.

Mr. Dickinson: I hope when Mr. Ward gives us the concluding part of his paper he will be able to announce that he is also prepared to send copies of these old plans to the Mining Record Office, where they will be preserved and open to the public for inspection.

Mr. Ward: They are very numerous.

NOTES ON Messrs. BARNES AND HOLROYD'S PAPER ON "A SEA BEACH AT CASTLETON."*

By Professor Hull, F.R.S., F.G.S.

I have been much interested by reading this paper. There can be no doubt, as it appears to me, that the authors have made out their case as regards the existence of a shallow water beach in the upper beds of the Carboniferous Limestone at Castleton, but I cannot quite concur with them regarding its character and mode of formation. The district in question must have been far removed from any marginal land, either that lying to the south or north-west. The actual discovery of a mass of Pre-carboniferous rock in the

* Published in the Society's Transactions, Vol. XXV., page 119.

vicinity of this part of England would be of great interest, but its presence here would have to be shown on clearer evidence than that adduced by the authors. The explanation which appears to me sufficient in the present case is to suppose a condition of things, somewhat resembling that of the margin of an atoll or coral-reef, rising out of the ocean, and distant from any permanent land. In such cases the coral-rock, together with the shells of molluscs, &c., are broken by wave-action, and piled up somewhat as in the case of the Castleton rock. It is easy to suppose such an occurrence in the case of the upper beds of the Carboniferous Limestone of Derbyshire, owing either to a slight local upward movement of the sea-bed or some other cause, the material having been thus brought within reach of wave or tidal action with the result of breaking it up, and converting it into a limestone conglomerate such as the authors have so well described.

As regards "Hull's Central Barrier" (which after all was first suggested by Jukes), on which the President, Mr. Mark Stirrup, seems to throw some doubt, allow me to say there is no fact more clearly demonstrated in the physical geology of England and Wales. It is fifteen years (1882) since the physical maps of the Carboniferous period (made use of in the paper of Messrs. Barnes and Holroyd) were constructed, and all more recent researches by boring, &c., have only tended to confirm the existence of the "barrier," and to extend its dimensions.*

Mr. Holroyd read the following observations on Professor Hull's communication :—

---

* The reader may be referred to the Authors' paper on "The Eastern Limits of the Midland Coalfield." Trans. Fed. Inst. M.E., Vol. II., p. 9, 1896.

Reply to Prof. Hull's Criticism on

THE PAPER ON "A SEA-BEACH AT CASTLETON."

By Messrs. Barnes and Holroyd.

In reply to Professor Hull's criticism of our paper, in which he doubts the presence of permanent land to the north-west of Castleton during the time of the deposition of the shelly conglomerate, we wish to point out that in Vol. XXV., Part IV., of the Trans. Manch. Geol. Soc., page 123, it was stated by us that we were uncertain as to the existence of any extensive area of permanent land, and we had, even then, from our observations of these shallow water deposits, the possibilty in our minds of the sea-beach at Castleton not bordering continental land but probably some submarine bank.

In our second paper, which Professor Hull has not seen, and which is to be found in Vol. XXV., Part VI., Trans. Manch. Geol. Soc., 1897, we stated most positively, and must still maintain this hypothesis, of permanent land, as it is proved by the presence of the rolled limestone pebbles which must have been derived from other beds than the later and upper ones which we find deposited at Castleton and in the adjacent districts.

Since reading the second paper on this subject referred to above we have made some further observations in other localities, and are able to say that we have found similar evidences at Buxton, and that Dr. Wheelton Hind called our attention to the occurrence of the sea beach at Waterhouses, near Leek, which place we have since visited and examined.

This place is on the western outcrop of the Mountain Limestone, and we find again the sea beach with its well rolled shells, and just as at Windy Knoll, there are also rolled pebbles of finer grained limestone, and what is still more important and conclusive with regard to permanent land is that there are also large blocks of this finer grained limestone, in size two feet long by one foot in thickness, which must have been fragments broken from cliffs or land elevated above the sea level.

It may be argued by some that as we have numerous evidences of volcanic activity, such as is shown by the presence of toadstones and tuffs embedded in the limestone, that the blocks referred to may have been ejected by volcanic action. If we grant this, then we ought to find, along with the blocks, some additional evidence in the form of ejected volcanic material such as ash, scoriæ, agglomerate, and lava ; but we have never, in any locality which we have examined, found any such mixture of rock substances along with beach material. Therefore this volcanic hypothesis falls to the ground.

It would be important and very interesting also to know exactly whether the foraminiferal remains, mentioned in our former paper as being found in the rolled pebbles, belong to Devonian or Silurian age, or whether they are characteristic of the older Carboniferous Limestone from which we believe they have been derived, and at what probable depth these creatures lived.

Another place at which we have seen evidence of the rolled shells is on the south side of the Carboniferous Limestone outcrop near Tissington. The finding of these materials on the three sides of the exposed area of the limestone of Derbyshire and Staffordshire seems to give some grounds to Professor Hull's view of the matter as to the existence of

an atoll, since we have examined this area on the north, west, and south.

We cannot yet say positively whether the material is to be found all along the eastern exposure, for we have not yet examined the whole of it, but we are carrying on such investigations as will enable us later on to speak more decidedly upon the matter.

It would be extremely interesting, as Professor Hull in his notes observes, if we could have discovered in the limestone area any signs of the presence of Pre-carboniferous rocks, such as Devonian or Silurian, but to this we make no claim, but only to the fact that there must have been some portion of the Carboniferous Limestone sea-floor elevated until it became land, and that on the sea border of this elevation we had in the shallow water and on the beach an accummulation of shell conglomerate and rolled pebbles.

But the uplifted land can scarcely have been very remote from some mainland. Silurian rocks have been proved at Northampton, and according to the map showing land and water areas in lower carboniferous age (the correctness of which Professor Hull insists upon) we had land in the middle of Wales, and in the Cumberland Lake district, not a greater distance from Castleton than is the Barrier Reef from the mainland of the eastern Australian Coast.

We are glad to observe that Professor Hull agrees in the main with our deductions, viz., that the limestone at Castleton and the adjacent neighbourhood are a shallow and not a deep water deposit, and his remarks are certainly such as will encourage us to continue the examination of all attainable evidence bearing upon the mode of deposition and derivation of the Upper Carboniferous Limestone.

The PRESIDENT said: In my remarks about the Central barrier I did not deny the existence of ancient rocks, as suggested by Professor Hull. My observation was simply that any influence the central barrier might have had was of an indefinite character on the physical topography of the district, at that time; and that therefore great caution was necessary in drawing definite conclusions from what I called very indefinite premises. That was all I intended to convey.

Professor DAWKINS: It seems to me that the central barrier is rather too far to the south to have had any influence on this question. I quite agree with the view which the authors of this very interesting paper have taken, that it is in all probability an accumulation on a submarine bank.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XII. VOL. XXV. SESSION 1897-98.

The ANNUAL MEETING of the Members was held on Tuesday, October 13th, 1897, at the Society's Rooms, Queen's Chambers, 5, John Dalton Street.

The President: Mr. MARK STIRRUP, F.G.S., in the Chair.

THE REPORT OF THE COUNCIL AND FINANCIAL STATEMENT.

Mr. WILLIAM SAINT, one of the Hon. Secretaries, read the Report of the Council for the past year, as follows :—

REPORT OF THE COUNCIL,

FOR SESSION 1896-1897.

The Council in presenting the Fifty-ninth Annual Report, are pleased to be able to congratulate the members upon the valuable results of the year's work.

Many important papers, published in the Transactions of the Society, have been brought before the members and discussed by them with intelligent interest.

That the Society fills an indispensable position in the intellectual and practical life of the city and neighbourhood

is manifest by an eventful existence of nearly sixty years—a period which has seen a great advance in the art of mining; and in the appreciation, by the public, of Geology as an important branch of Natural Science.

In order to utiilize the new rooms of the Society to more advantage, and to meet the request of some members who have not the opportunity of attending the monthly afternoon meetings; the year's programme included the institution of occasional evening meetings. Two of these were held and fairly attended, and their continuance is recommended to the consideration of the incoming Council.

During the sessional year twenty-one new members have joined the Society. We have lost four members by death, and eight by resignation; thus showing a net increase of nine members.

The deaths, which we all deplore, include Mr. W. J. Greener who, unfortunately, was fatally injured below ground at Pemberton Colliery.

The Society now consists of:—

Honorary Members..	12
Life Members	9
Ordinary Members..	217
Total	238

The Annual Meeting, six Ordinary and two Special Evening Meetings were held in the Society's Rooms. Two Ordinary Meetings were held, as usual, in the Mining School, Wigan.

A list of the Papers and Communications which have been read and published during the past session, is appended to this Report.

The Council thank the President for his highly interesting Address on "The Early History of the Manchester Geological Society," whose founders were some of the most prominent men in the town and adjoining districts; and also the Authors for their respective Papers, some of which are important contributions to our knowledge of Geology, while others relate to the application of scientific and mechanical invention for the purpose of insuring the safe and economical working of mines; the whole forming a valuable addition to the Society's Transactions upon which the members may be congratulated.

The Treasurer's Statement of Accounts is appended.

During the past two years the expenditure has unavoidably increased in connection with the occupation of the present rooms, chiefly for Rent, Rates, Taxes, and Room Attendant. In order to meet these extra charges without disturbing the invested funds of the Society, the Council would urge upon the members generally, the importance of obtaining additional members whose subscriptions, added to the present income, would ensure the maintenance of the Society in a sound financial position.

With the foregoing object in view, the Honorary Secretaries, in May last, by direction of the Council sent a circular letter, a copy of which is appended to this Report, to some of the Mineral Royalty Owners and Lessees in Lancashire, who had not then joined, calling their attention to the valuable work of the Society, and requesting their co-operation and support in aid of the Society's objects. It is hoped that from this effort, considerable additions to the roll of members may be made. The subscription of £1 a year to the Society entitles members to the use of well furnished rooms, situate in a central position in Manchester, containing a valuable library of standard Geological and Mining works, and

to a copy of the Transactions and other publications as issued.

The publications of the various Societies, at home and abroad, with whom we exchange Transactions, continue to be received. These together with the Library and the Geological Maps of the District on the One Inch and Six Inch Scales, form a valuable source of reference to those interested in Geology and Mining.

The donations to the library during the year include a further series of standard Geological works by our Honorary Member Mr. William Whitaker, F.R.S., and a finely illustrated work entitled—"Irelande et Cavernes Anglaises," by the author M. Martel.

Two excursions took place during the summer.

The first, the outcome of Papers published in Part X., Vol. XXIV., and Part IV., Vol. XXV., was made on the 19th of June, to Castleton, in Derbyshire, under the leadership of Messrs. Holroyd and Barnes. About twenty members were present. Proceeding up the Winnatts and thence to Windy Knoll, many interesting features were observed and discussed. The deposit of elaterite or bitumen; the superposition of the Yoredale Shales upon the Limestone in the quarry; and the fissure or cave of Windy Knoll, productive of so many pleistocene bones, were examined and described. The party visited the "Blue John" Mine, where most of the members descended into the workings. The "Blue John" (Fluor Spar) was seen *in situ*. The Stalactites, Stalagmites, &c., were shown by means of the magnesium ribbon and the reflector. The course of the underground water, and the mode of erosion by the carbonic acid were discussed. The other members viewed the opencast workings of "Blue John," and the outcrop of fossiliferous limestone on the hillside. The party then

wended their way down Tray Cliff, and were shown what is called the "Sea Beach," or bed of limestone with its rolled shells and pebbles in a quarry at the foot of the hill, and also in another quarry nearer Castleton on the right.

The second excursion was the outcome of a Paper published in Part V., Vol. XXIV., and was made on the 17th of July, to Pule Hill and Netherley, near Marsden, under the leadership of Mr. Holroyd to revisit the Yoredale Shales exposed there, and also to see a remarkable quarry in the Millstone Grit in which fossil shells are very abundant. There was a good attendance. The party walked from Diggle over the top of Standedge Moor, and through the cutting to Pule Hill. At the shaft tips a number of Yoredale fossils were found by the members, and named by Mr. Holroyd. Crossing the Moor to the right, Netherly quarry was reached, and an abundance of the rare Millstone Grit fossils were collected.

The cordial thanks of the Society are due to the Governors of the Mining School, Wigan, for their kindness in granting the free use of the lecture hall in which the January and May meetings were held.

In conclusion the Council have pleasure in acknowledging their obligations to those members and friends who have so ably assisted in promoting the welfare of the Society, and they confidently appeal to the general body of members to take their due share in advancing the objects of the Society, namely:—"The collection and diffusion of practical and theoretical knowledge respecting Geology and Mining."

The following abstract of the Treasurer's accounts was also read:—

Dr. MANCHESTER GEOLOGICAL SOCIETY.—BALANCE SHEET. *Cr.*

Abstract of Receipts.	£	s.	d.
To Birkenhead Railway Dividend	11	12	0
,, ,, ,, ,,	11	12	0
,, Lancashire & Yorkshire Railway Dividend	10	12	8
,, ,, ,, ,, ,,	10	12	8
,, Sir U. K. Shuttleworth	1	0	0
,, Colliery Managers' Association Rooms	2	10	0
,, Marshall, Gibbon & Co., Collectors	185	0	0
,, Bank Interest	0	4	11
,, County Fire Office—Returned	0	12	6
,, Balance due to Treasurer	36	4	3
	£270	1	0

Abstract of Payments.	£	s.	d.
By Balance due to Treasurer—brought forward	6	8	0
,, Library	3	6	8
,, Transactions	80	12	5
,, Circulars and Stationery	11	0	7
,, Reporters	10	10	0
,, Expenses of Rooms, Rent, &c.	116	18	0
,, Postage	19	1	4
,, Electric Lighting	6	1	0
,, Type-writing	0	2	6
,, County Fire Office—Insurance	0	12	6
,, New Furniture	6	2	0
,, Collector's Commission	9	6	0
	£270	1	0

The Investments consist of £600 Four per cent. Guaranteed Stock of the Birkenhead Railway Co., and £550 of the Lancashire and Yorkshire Railway Co.'s Consolidated Four per cent. Preference Stock.

October 7th, 1897.

CLEGG LIVESEY, Treasurer.

Audited and found correct,

G. A. HOLLINGWORTH,
H. A. WOODWARD, } Auditors.

The PRESIDENT asked if any member desired to make any comments upon the report before he put it to the meeting for adoption. They must all, he said, regret to find from the Treasurer's statement that there was an unusual amount due in outstanding subscriptions. It exceeded the amount overdue at the corresponding date last year by £18. It was hoped gentlemen in arrears would pay their subscriptions at once, and so help the Society to maintain its usually sound financial position. He moved that the report and abstract of accounts be received and adopted.

The motion was seconded by Mr. Ashworth, and unanimously passed.

ELECTION OF OFFICERS.

The PRESIDENT said: The next business is to elect a President and Members of the Council for the coming year. A list of those recommended, attached to the circular calling this meeting, has been sent to each member of the Society, but it is open, as you are all aware, for any member to propose any other member or members in place of those nominated by the retiring Council. Mr. John Ridyard, who is proposed as President for the coming year is an old member of the Society. He writes to Mr. Saint, from Paris, apologising for his absence, and saying that he has been detained there, but that he hopes no inconvenience will be occasioned by his absence. I may add that there is also a letter from Mr. Platt regretting that he is not able to be with us to-day.

The question of Mr. Ridyard's election as President was then put to the meeting and carried unanimously.

The following gentlemen were elected Vice-Presidents in addition to the ex-officio Vice-Presidents namely:—John Gerrard, H.M.I.M.; S. S. Platt, F.G.S., M.Inst.C.E.; Mr. W. N. Atkinson, H.M.I.M.; and Mr. S. Garside.

Mr. Clegg Livesey, J.P., was re-elected Honorary Treasurer.

Mr. William Saint, and Mr. George H. Winstanley, F.G.S., were unanimously elected Honorary Secretaries.

Mr. STIRRUP in submitting the names of other members of the Council nominated for election, said the Council had been guided in their recommendations by a desire that all branches of the Society should be represented. The names submitted were probably as good a selection as could have been made.

The following gentlemen, being those nominated by the Council, were unanimously elected :—Mr. James Atherton, Mr. J. Barnes, F.G.S., Mr. E. O. Bolton, Mr. George Caldwell, Mr. Joseph Crankshaw, Mr. G. B. Harrison, H.M.I.M., Mr. W. F. Holroyd, F.G.S., Mr. C. R. Lindsey, B.Sc., Mr. D. W. F. Matthews, H.M.I.M., Mr. George Peace, Mr. T. Scowcroft, Mr. Thomas Ward, J.P., F.G.S.

The following Past-Presidents continue ex-officio members of the Council:—James Heywood, F.R.S., R. Clifford Smith, F.G.S., H. M. Ormerod, F.G.S., the Right Hon. the Earl of Crawford and Balcarres, Sir U. K. Shuttleworth, Bart., G. C. Greenwell, F.G.S., M.Inst.C.E., Edward Pilkington, J.P., Professor W. Boyd-Dawkins, M.A., F.R.S., F.G.S., Joseph Dickinson, F.G.S., Henry Hall, H.M.I.M., John S. Burrows, F.G.S., James Tonge, F.G.S., Assoc.M.Inst.C.E., W. Saint, H.M.I.M., Robert Winstanley, C.E., W. Watts, F.G.S., Mark Stirrup, F.G.S.

The Honorary Auditors, Messrs. G. H. Hollingworth, F.G.S., and H. A. Woodward, were re-appointed, Mr. Stirrup remarking that both gentlemen had punctually attended to their duties and done their work exceedingly well.

NEW ORDINARY MEMBERS.

The following gentlemen were ballotted for and unanimously elected ordinary members of the Society :—Mr. J. S. Caldwell, Manager, Westhoughton New Colliery, Westhoughton, Bolton; Mr. W. F. Wood Ellis, M.Inst.M.E., M.S.A., 2, Dulal Street, Bombay; and 5, John Dalton Street, Manchester; Mr. Walter Evans, J.P., M.E., Royton; Mr. Thomas Walton, Manager, Habergham Colliery, Burnley; Mr. Lionel B. Wells, M.Inst.C.E., 5, John Dalton Street, Manchester; Mr. Percy Lee Wood, Newtown Collieries, Clifton, Manchester.

Mr. Stirrup expressed a wish that as good a list of candidates for membership might be announced for election at next month's meeting. He hoped members would bring the advantages of the Society under the notice of their friends, and endeavour to induce them to join. Gentlemen who might have papers in view for the coming Session were invited to give early intimation to the Hon. Secretaries. Some papers were already in hand and others had been promised.

PROPOSAL TO ELECT AN HONORARY MEMBER.

Mr. Stirrup called attention to the following statement which appeared in the circular :—"The following gentleman has been nominated by the Council as an Honorary Member of the Society, and will be ballotted for at the Meeting to be held on Tuesday, November 9th :—Mr. George Wild, Albert Street, Bardsley, Ashton-under-Lyne." The gentleman named, Mr. Stirrup said, is not unknown to any of you. For a long time he attended regularly the meetings of this Society, and he contributed largely to our knowledge of the

fossils of the Lancashire coalfield, and the Council desire to honour him for what he has done by electing him an Honorary Member of the Society.

Professor Boyd-Dawkins said: I should like to speak in support of that proposal. I feel strongly that we owe, as the Manchester Geological Society, our gratitude to Mr. George Wild for the many papers and communications which he has laid before us. I would say also that he has been a benefactor to our Museum in Owens College; and when I say our "Museum," I speak as a member of the Geological Society as well as one of the Professors of the College. I feel that, as Mr. Wild has been a member of this Society for so many years, and has done such good work—and also because we have been able to acquire his collections for our Museum in the College—it would be a very graceful thing for us to appoint him an Honorary Member. I think he has fully earned that position by his work, and we cannot do less than accept the proposal which is to be submitted to us at the next meeting.

Mr. Dickinson added a few words in support of the proposal, and stated that the Council were unanimously of opinion that Mr. Wild's services entitled him to election as an Honorary Member. He had fully earned it.

Mr. Stirrup: He has indeed. If more gentlemen connected with collieries would take the same interest in the collection of fossils as Mr. Wild had done, we should be in a happier position with regard to our knowledge of the fauna and flora of the coal measures than we are at present. I may have something to say about the Coal Measure plants of Lancashire at our next meeting, and I hope, by showing what has been done elsewhere, to induce some of our members to do something in the same direction. As you know, this question of compiling a full account of all the

fossils of the Lancashire coalfield is one which I brought before the Society some years ago. Something was done at the time, but much more was left undone, and it is waiting, I think, for some gentleman of the calibre and industry of Mr. Wild to undertake. I hope some of the younger geologists who are connected with mining, will emulate the good example of our friend Mr. Wild.

VOTES OF THANKS.

Mr. Gerrard said: I have been asked sir, as this is the last meeting over which you will have the honour to preside, to propose that we give to you our heartiest thanks for the distinction you have conferred upon the Society by the admirable way in which you have fulfilled the duties of President during the past year. The creditable position the Society now holds in Lancashire, as to its membership, the admirable work of the session now closed—the excellent character of the papers contributed, and the interesting discussions that have taken place—I am sure the Society will feel—are largely due to the interest you have taken in the good work of this admirable Society; and I, in response to the request which has been made to me, have great pleasure in proposing a hearty vote of thanks to you.

Mr. John Ashworth: I have very great pleasure in supporting the remarks of Mr. Gerrard, and in seconding the motion he has made. It is one which I am sure all the members of the Council will endorse.

Mr. Gerrard put the motion to the meeting, and it was carried unanimously.

Mr. Stirrup returned thanks for the resolution, remarking that he had simply done what he could in the best interests of the Society, from the esteem he felt in its

work. That had always been his endeavour, whatever position he had filled during his long connection with the Society. He was pleased if what he had done had met the appreciation of the Council and members.

Mr. Dickinson said he had pleasure in moving that a similar vote of thanks be given to the members of the Council and Honorary Officers of this Society for the valuable services they had rendered.

The motion was seconded by Professor Boyd-Dawkins, and passed unanimously. Mr. Stirrup remarking that the Society was particularly indebted to the Honorary Secretaries upon whom a large part of the labour fell.

This concluded the business of the Meeting.

LIST OF PAPERS AND SHORT COMMUNICATIONS

WHICH HAVE BEEN BROUGHT BEFORE THE

SOCIETY DURING THE SESSION 1896-97.

1896

November. Stirrup, Mark. "The International Congress of Geologists."

"On the Early History of the Manchester Geological Society, with some remarks on Speculative Geology."

December. Bell, Thomas. "Further Remarks on the Durham and Cleveland Salt Districts."

Meacham, Frederick G. "On Irruptions of Coal into the 'Thick Coal' Workings at Hamstead Colliery, South Staffordshire."

Gresley, W. S. "Remarks on some interesting Coal Measures Sections in the Leicestershire and South Derbyshire Coalfield."

Stirrup, Mark. "Report of the Delegate to the Meeting of the British Association at Liverpool."

Hall, Henry. "Boring for Coal at Bold, St. Helens."

(Special Evening Meeting.) Barnes, J., and Holroyd, W. F. "Some Experiments with regard to effects of pressure upon Decaying Vegetable Matter.

"On the occurrence of a Sea-Beach at Castleton, Derbyshire, of Carboniferous Limestone Age."

1897.

January. Winstanley, George H. "The Improved Fleuss Breathing Apparatus."

February. Dawkins, Prof. W. Boyd. "On the History of the Discovery of the South-Eastern Coalfield."

Watts, William. "On the Earthquake Tremors in December, 1896."

"Notes on the recent Slipping Peat in Ireland."

Hobson, Bernard. "On Evidences of Glacial Action in Australia in Permo-Carboniferous time."

March. (Special Evening Meeting.) Barnes, J., and Holroyd, W. F. "Further Notes on the Sea-Beach in Carboniferous Limestone, Derbyshire."

"On the occurrence of Lamellibranchiata, Gasteropoda and Cephalopoda, in the Millstone Grit of South Yorkshire."

(Ordinary Meeting.) Dickinson, Joseph. "The Flooding of a Colliery Shaft at Dover."

Capell, Rev. G. M. "On the Increase of Fan Gauges in Mine Ventilation of the Present Day, with some Notes on Ventilation."

De Rance, C. E. "On the Permo-Carboniferous Boundary."

April. Caldwell, George. "Notes on the Sinking at the Maypole House Colliery, Abram, with Specimens of Rock and an Analysis of the Water found in the Shafts."

Sutcliffe, Richard. "Notes on the Yorkshire Coalfield."

May. Orsman, W. J. "Detonators and Detonation."

Tonge, James. "A new Hydraulic Apparatus for Breaking Down Coal in Mines."

June. Ward, Thomas. "The Rock Salt Deposits of Northwich, Cheshire, and the Results of their Exploitation."

Hull, Prof. Edward. "Notes on Messrs. Barnes and Holroyd's Paper, 'On a Sea-Beach at Castleton.'"

Barnes, J., and Holroyd, W. F. "Reply to Prof. Hull's criticism on the Paper 'On a Sea-Beach at Castleton.'"

NEW ORDINARY MEMBERS.

Allen, Edward
Baker, Godfrey
Brooks, Hon. William
Fletcher, Leonard R.
Fletcher, Norman
Harris, George E.
Hobson, Bernard
Howsin, Evelyn G.
Humphrey, Robert
Keirby, John E.
Lees, Frederick
McCallam, Theo. S.
Makepeace, H. R.
Noar, L. Lamb
Pearce, Charles
Reid, Alexander
Richardson, Isaiah
Scholes, Thomas
Turner, William
Whewell, John, jun.
Winstanley, George H.

MEMBERS DECEASED.

Beck, William
Greener, W. J.
Pickup, P. W.
Pilkington, Alfred

MEMBERS RESIGNED.

Brierley, Brandon T.
Cockson, Charles
Hall, Jonathan
Hilton, James
Holden, Arthur T.
Horrobin, Thomas
Toman, Daniel
Wilkinson, Fred.

Copy of the letter referred to in the Report:—

MANCHESTER GEOLOGICAL SOCIETY.

ESTABLISHED 1838.

Queen's Chambers, 5, John Dalton Street,
Manchester, May, 1897.

Dear Sir,

The Council of the Manchester Geological Society have the honour to present to you a copy of the recent Inaugural Address of the President "On the Early History of the Society," whose foundation dates back almost to the commencement of the reign of Her Majesty the Queen.

In soliciting your support, it may be mentioned that the members consist of Geologists, Lessors of Minerals, Owners, Agents, Managers, Engineers, and others connected with Mines and Minerals.

The Rooms now occupied by the Society offer a convenient place of call in a central part of Manchester, are comfortably furnished, and lighted by electricity.

The Library contains a valuable collection of scientific and practical books, charts, sections, and the Geological Survey Maps of Lancashire, &c.

Meetings are held monthly during the Session, with occasional ones in the evening, at which original papers are read and Geological and Mining subjects discussed. All the important papers are printed by the Society and issued to the members, by which much useful knowledge is spread.

Visits to Mines and Geological Excursions are also included in the scheme of the Society's work.

The Annual Subscription is One Pound, without any entrance or other fee; Life Membership, Ten Pounds.

Your co-operation would be valuable and much appreciated. Kindly say, therefore, whether we may have the pleasure of enrolling you amongst the members.

We are,

Your obedient Servants,

WILLIAM SAINT,
JAMES TONGE,
Honorary Secretaries.

The following is the complete list of the Council for the ensuing year :—

President:

JOHN RIDYARD, F.G.S.

Vice-Presidents:

JOHN GERRARD, H.M.I.M. | W. N. ATKINSON, H.M.I.M.
S. S. PLATT, F.G.S., M.Inst.C.E.
SAMSON GARSIDE.

Ex-Officio Vice-Presidents:

JAMES HEYWOOD, F.R.S. | R. CLIFFORD SMITH, F.G.S.
H. M. ORMEROD, F.G.S.
The Right Hon. the EARL OF CRAWFORD & BALCARRES.
Sir U. K. SHUTTLEWORTH, Bart.
EDWARD PILKINGTON, J.P.
Professor W. BOYD-DAWKINS, M.A., F.R.S., F.G.S.
JOSEPH DICKINSON, F.G.S.
G. C. GREENWELL, F.G.S., M.Inst.C.E.
HENRY HALL, H.M.I.M. | JOHN S. BURROWS, F.G.S.
JAMES TONGE, F.G.S., Assoc.M.Inst.C.E.
W. SAINT, H.M.I.M. | W. WATTS, F.G.S.
ROBERT WINSTANLEY, C.E. | MARK STIRRUP, F.G.S.

Hon. Treasurer:

CLEGG LIVESEY, J.P.

Hon. Secretaries:

WILLIAM SAINT, H.M.I.M. | GEORGE H. WINSTANLEY, F.G.S.

Other Members of the Council:

JAMES ATHERTON.
J. BARNES, F.G.S.
E. O. BOLTON.
GEORGE CALDWELL.
J. CRANKSHAW.
G. B. HARRISON, H.M.I.M.
W. F. HOLROYD, F.G.S.
C. R. LINDSEY, B.Sc.
D. W. F. MATTHEWS, H.M.I.M.
GEORGE PEACE.
T. SCOWCROFT.
THOMAS WARD, J.P., F.G.S.

Hon. Auditors:

G. H. HOLLINGWORTH, F.G.S. | H. A. WOODWARD.

APPENDIX TO THE REPORT.

PRESENTATIONS TO THE LIBRARY, 1896-7.

Barnsley.—Midland Institute of Mining, Civil, and Mechanical Engineers. Proceedings. Included in the Transactions of the Federated Institution of Mining Engineers. *From the Institution.*

Belfast.—Natural History and Philosophical Society. Report and Proceedings for Session 1895-6. *From the Society.*

Cambridge.—Museum. 30th Annual Report Museums and Lecture Rooms' Syndicate for 1895; also 31st for 1896, also Report of Comparative Geology, 1895-6. *From the Woodwardian Museum.*

Cardiff.—Naturalists' Society. Part 1-2, Vol. XXVIII. *From the Society.*

Chester.—Society of Natural Science and Literature. 26th Annual Report. *From the Society.*

Chesterfield and Midland Counties Institute of Engineers.—Transactions. Included in the Transactions of the Federated Institution of Mining Engineers. *From the Institution.*

Cornwall.—Royal Geological Society. Transactions. Part 2, Vol. XII. *From the Society.*

Essex.—Journal of the Essex Field Club. Parts 1, 5, 6, 10, 11, 12, Vol. VIII. Parts 1-24, Vol. IX., and Parts 1-4, Vol. X.

Edinburgh.—Royal Physical Society. Proceedings for the Session 1895-6. *From the Society.*

Glasgow.—Natural History Society. Part 3. Vol. IV. *From the Society.*

Glasgow.—Transactions of the Geological Society of Glasgow. 1894-5 and 1895-6.

Hamilton.—Mining Institute of Scotland. Transactions. Included in the Transactions of the Federated Institution of Mining Engineers. *From the Institution.*

Hertford.—Transactions of the Natural History Society. Parts 8 and 9. Vol. VIII., and 3, Vol. IX.

Leeds.—Philosophical and Literary Society. 77th Annual Report.

Leeds.—Yorkshire Naturalists' Society. Transactions. Vol. XX. *From the Society.*

Leicester.—Literary and Philosophical Society. Transactions. Parts 6, 7, 8, 9, Vol. IV., New Series. *From the Society.*

Liverpool.—Report of the British Association, 1896.

London.—Geological Catalogues and Guides, British Museum. *From the Museum.*

London.—"Our Coal Resources at the close of the 19th century." By Ed. Hull, LL.D., F.R.S., F.G.S. *From the Author.*

London.—Royal Society. Proceedings. Parts 362-368, Vol. LX.; and Parts 369-379, Vol. LXI. *From the Society.*

London.—Institution of Mechanical Engineers. Proceedings. Nos. 2 and 3 for 1896. *From the Institution.*

London.—Geological Society. Quarterly Journal. No. 208, Vol. LII.; and Nos. 209, 210, 211, Vol. LIII. Also General Index to the first 50 Vols. *From the Society.*

London.—Geologists' Association. Proceedings. Part 10, Vol. XIV.; and Parts 1, 2, 3, 4, Vol. XV. *From the Association.*

London.—Geological Magazine.—Nos. 389 and 390, Vol. III.; also 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 (new series), Vol. IV. *Purchased.*

London.—Iron and Steel Institute. Journal. Part 2. Vol. L. *From the Institute.*

London.—Royal Institution of Great Britain. Proceedings. Part 1, Vol. XV. *From the Institution.*

London.—The Mining Journal. Nos. 3202-3244, Vol. LXVII.

London.—The Colliery Guardian. Nos. 1879, Vol. LXXIII., to 1921, Vol. LXXIV.

London.—Iron and Coal Trades Review. Nos. 1505, Vol. LIV., to 1547, Vol. LV.

Manchester.—Literary and Philosophical Society. Memoirs and Proceedings. Parts 1, 2, 3, and 4, Vol. XI. *From the Society.*

Manchester.—Geographical Society. Journal. Nos. 1-9, Vol. XII. *From the Society.*

Manchester.—Field Naturalists' Society. Report and Proceedings for 1896. *From the Society.*

Manchester.—Owens College Museum, Report for the year, also Notes from the Manchester Museum. *From the College.*

Manchester.—Microscopical Society. Annual Report, 1896.

Newcastle-upon-Tyne.—Federated Institution of Mining Engineers. Part 3, Vol. XI.; Parts 1, 2, 3, Vol. XII.; Parts 1 and 2, Vol. XIII. *From the Institution.*

Newcastle-upon-Tyne.—North of England Institute of Mining and Mechanical Engineers. Transactions. Included in the Transactions of the Federated Institution of Mining Engineers; also Annual Report. *From the Institution.*

Salford.—Annual Report of the Museum, Libraries, and Parks Committee, 1895-96.

Stoke-on-Trent.—North Staffordshire Institute of Mining and Mechanical Engineers. Proceedings. Included in the Transactions of the Federation Institution of Mining Engineers. *From the Institution.*

Swansea.—South Wales Institute of Engineers. Proceedings. Parts 2, 3, 4, and 5, Vol. XX. *From the Institute.*

Wigan.—Science and Art of Mining. Nos. 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, Vol. VII.; and Nos. 1, 2, 3, 4, Vol. VIII.

PAMPHLETS AND REPORTS.—ENGLISH AND FOREIGN.

Report on Minerals and Mining in New Zealand.

Bradford Free Libraries 26th Annual Report. *From the Committee.*

Report on the Inspection of Mines in India for 1896. By James Grundy. *From the Author.*

Mineral Statistics of the Mines and Quarries for 1896; also Annual Report for S.W. district. *Presented by Joseph S. Martin.*

H.M. Inspector's Report of Mines and Quarries, 1896. London.

Mineral Statistics of Great Britain, and the Isle of Man. London, 1895.

Twentieth Annual Report of the Department of Geological and Natural Resources. Indiana, 1895.

INDIA.

Calcutta.—Records of the Geological Survey of India. Part 4, Vol. XXIX.; and Parts 1 and 2, Vol. XXX. *From the Governor General in Council.*

AUSTRALIA.

Adelaide.—Royal Society of South Australia. Transactions. Parts 1 and 2, Vol. XX.; also Part 1, Vol. XXI. *From the Society.*

Sydney.—The Australian Mining Standard: A Record of Mining, Financial, and Engineering Progress, Nos. 411-425, Vol. XII., and Nos. 426-462, Vol. XIII. *From the Editor.*

Sydney.—Geological Survey of New South Wales: Department of Mines. Records, Part 2, Vol. V.; Annual Report Department of Mines and Agriculture, New South Wales for 1896. *From the Hon. the Minister of Mines.*

Sydney.—Royal Society of New South Wales Journal and Proceedings, Vol. XXIX., 1895; also Vol. XXX., 1896.

CANADA.

Halifax, N.S.—Nova Scotian Institute of Science. Proceedings and Transactions. Part 2, Vol. IX., 2nd series. *From the Institute.*

Hamilton.—Journal and Proceedings of the Hamilton Association, 1896-7.

Ottawa.—Canadian Mining Review. Nos. 10-12, Vol. XV.; and Nos. 1-9, Vol. XVI. *From the Editor.*

Ottawa.—Geological and Natural History Survey of Canada. Vol. VII., and Vol. VIII.; also Maps. *From the Director of the Survey.*

St. John, New Brunswick.—Natural History Society of New Brunswick. Bulletins 14 and 15. *From the Society.*

Toronto.—Canadian Institute. Transactions. Parts 1-2, Vol. V.; also Part 1, Vol. I. (new Series). *From the Institute.*

Toronto.—Royal Society of Canada. Transactions. Section IV., Vol. II.

U.S. AMERICA.

California.—Berkeley University of California. Bulletin of the Department of Geology, Nos. 12, 13, 14, Vol. 1.

Cambridge.—Harvard College. Bulletin of the Museum of Comparative Zoology. Nos. 2 and 3, Vol. XXVIII., and Nos. 1, 2, 3, 4, 5, 6, Vol. XXX. *From Alex. Agassiz.*

Chicago.—Academy of Science. Bulletin and Annual Report. *From the Academy.*

Chicago.—Field Columbian Museum; Sundry Manuals, &c.; also Annual Report. Part 2, Vol. I., 1896.

Denver.—Colorado Scientific Society. Proceedings and Pamphlets. *From the Society.*

Houghton.—Michigan Mining School Reports, &c., 1894-1896.

Iowa.—Geological Survey of. Vol. V. *From the Director of the Survey.*

Minneapolis.—The American Geologist. Nos. 5 and 6, Vol. XVIII., Nos. 1-4, Vol. XIX., and No. 3, Vol. XX. *Purchased.*

New York.—American Institute of Mining Engineers. Transactions. Vol. XXVI. *From the Institute.*

New York.—The American Museum of Natural History. Bulletin, Vol. VIII.; also Annual Report for 1896. *From the Museum.*

Philadelphia.—Franklin Institute. Journal. Nos. 851 and 852, Vol. CXLII., Nos. 853-858, Vol. CXLIII.; and Nos. 859-862, Vol. CXLIV. *From the Institute.*

Philadelphia.—Academy of Natural Sciences. Proceedings. Parts 2 and 3, 1896. *From the Academy.*

Scranton, Pa.—The Colliery Engineer. Journal. Nos. 4-11. Vol. XVII.; and Nos. 1 and 2, Vol. XVIII. *From the Editor.*

Washington.—Smithsonian Institute:—

Annual Report, 1895. Also Reports of the U.S. State Museum, 1893-4, and Annual Report of the Board of Regents, 1894.

Washington.

U.S.	Geological	Survey of	Mineral Resources of the U.S.
,,	,,	,,	16th Annual Report, 1894-95. Part 2.
,,	,,	,,	16th Annual Report, 1894-95. Part 3.
,,	,,	,,	16th Annual Report, 1894-95. Part 4.
,,	,,	,,	17th Annual Report, 1895-96. Part 3.
,,	,,	,,	17th Annual Report, 1895-96. Part 3 (continued).

FOREIGN.

Berlin.—Gesellschaft für Erdkunde: Zeitschrift, No. 5, Vol. XXXI.; Nos. 1, 2, 3, Vol. XXXII.; Verhandlungen, Nos. 8, 9, 10, Vol. XXIII.; Nos. 1, 2, 3, 4, 5, 7, Vol. XXIV. *From the Society.*

Berlin.—Zeitschrift der Deutschen Geologischen Gesellschaft. Heft 2, 3, 4, Vol. XLVIII.; Heft 1 and 2, Vol. XLIX. *From the Society.*

Buenos Ayres.—Anales del Museo National de Buenos Ayres. Ser. 2. Tomo. V.

Halle, A.S.—Mittheilungen des Vereins für Erdkunde, 1896. *From the Society.*

Lausanne (Suisse).—Société Vaudoise des Sciences Naturelles, Bulletin 121-123, Vol. XXXII.; and Bulletin 124-125, Vol. XXXIII. *From the Society.*

Lille.—Société Géologique du Nord. Annales, Vol. XXIII.

Mexico.—Sociedad Cientifica "Antonio Alzate." Memorias Y. Revista. Nos. 1-4, Vol. X.

Mexico.—Institute Geologico de Mexico. Bulletin Nos. 4-5, Vol. VI.

Naples.—Rendiconto dell Accademie Scienze Fisiche e Mathematiche. Nos. 3 and 4, Vol. II., 3rd Series; and 1-7, Vol. III. *From the Academy.*

Paris.—Bulletin Société de Spéléogique. No. 8, Vol. II.; and 1, Vol. III.

Roma.—Atti della Reale Accademia dei Lincei Rendiconti. Nos. 8-12, Vol. IV.; Nos. 1-12, Vol. V.; and Nos. 1-8, Vol. VI. Rendiconti Annual. *From the Academy.*

St. Petersburg.—Bulletin du Comite Geologique. Nos. 3-9, Vol. XV.; and 1 and 2, Vol. XVI.; also Supplement to Vol. XV.; also Memoires.

St. Petersburg.—Société Impériale Mineralogique (Institute des Mines), 1896. Vol. XXXII.

St. Petersburg.—Bulletin de L'Académie Impériale des Sciences de St. Petersburg. V. Series, Nos. 1, 2, 3, Vol. VI. *From the Academy.*

Societies with whom the Society Exchanges its Transactions and Institutions and Journals to whom a copy is sent free.

I.—England.

London .....British Museum, Superintendent of Copyright's Office.
British Museum Library, Natural History Department, Cromwell Road, Kensington.
Geological Society, Burlington House, W.
Geological Survey, Jermyn Street, S.W.
Geologists' Association, University College, Gower Street, W.C.
Institute of Mechanical Engineers, Victoria Street, S.W.
Iron and Steel Institute, Victoria Mansions, S.W.
Royal Institution of Great Britain.
Royal Society, Burlington House, W.
Public Library, Kensington, High Street, W.

Manchester.....The Manchester Association of Engineers, Grand Hotel, Aytoun Street.
Field Naturalists' Society, 16, Kennedy Street.
Free Library, King Street.
Literary and Philosophical Society.
Manchester Geographical Society, 44, Brown Street.
Owens College.
Salford Royal Museum and Library.

Barnsley.....Midland Institute of Mining Engineers.

Birmingham ....Free Library and Museum.
South Staffordshire and East Worcestershire Institute of Mining Engineers, Colmore Chambers, 3, Newhall Street.

Bradford .....Public Free Library, Bradford, Yorkshire.

Bristol .....Naturalists' Society, Clifton.

Cambridge .....Geological Museum, University.
University Library.

Cardiff .....Naturalists' Society, 44, Loundoun Square.
South Wales Institute of Mining and Mechanical Engineers, Park Place, Cardiff.

Chester .....Society of Natural Science.

Chesterfield.....Institution of Mining Engineers, 13, Cavendish Street.

Cornwall .....Royal Geological Society, Penzance.
Royal Institution. Truro.

Tuckingmill, Camborne .. } Mining Association and Institute of Cornwall.

Essex .....Essex Field Club, Chelmsford, Essex.

Exeter .....Albert Memorial Museum.

Leeds .....Philosophical and Literary Society.
Yorkshire Naturalists' Union (W. D. Roebuck, Esq., Hon. Librarian, 259, Hyde Park Road, Leeds).
Geological Association, Mechanics' Institution, Cookridge Street.

Leicester.....Literary and Philosophical Society.

Liverpool .....Free Library and Museum.
Geological Association, Free Library, William Brown Street.
Geological Society.
Science Students' Association, Royal Institution, Colquitt Street.

Mirfield .....Geological and Polytechnic Society of Yorkshire, Hoptown, Mirfield.

*Newcastle-on-Tyne*Federated Institution of Mining Engineers.
North of England Institute of Mining and Mechanical Engineers.

Newcastle, Staffordshire .. } North Staffordshire Naturalists' Field Club (Rev. T. W. Daltry, M.A., F.G.S., Madeley Vicarage).

Norwich .....Geological Society, Museum.

Oxford .....Bodleian Library.
Radcliffe Library.

North Shields....Public Free Library.

Rochdale.....Literary and Scientific Society, 20, King Street, South.

Southampton ....Hampshire Field Club, Harley Institution.

Stoke-on-Trent ..North Staffordshire Institute of Mining and Mechanical Engineers.

Warwick .....Natural History Society.

Watford, Herts ..Hertfordshire Natural History Society and Field Club, the Public Library, Watford (Daniel Hill, Esq., Hon. Librarian, Herga, Watford, Herts).

Wigan .....Free Library.
Mining School.

II.—Scotland.

Dundee .....Free Library and Museum.

Edinburgh .....Advocates' Library.
Geological Society.
Royal Society.
Royal Physical Society.

Glasgow .....Geological Society.
Natural History Society.

Hamilton .....Mining Institute of Scotland.

III.—Ireland.

Dublin .....Royal Dublin Society.
Royal Geological Society of Ireland.
Trinity College Library.

Belfast .....Natural History Society, the Museum.

IV.—Australia.

Adelaide .....Royal Society of South Australia (W. C. Rigby, 74, King William Street, Adelaide).

Melbourne .....Geological Society of Australasia, 17A, Queen Street.

Public Library of Victoria.

Sydney .....Free Public Library.

Royal Society of New South Wales, 37, Elizabeth Street.

Department of Mines.—The Honourable the Minister of Mines.

Australian Mining Standard, 108, Pitt Street.

V.—Canada.

Halifax, Nova Scotia ..... Nova Scotian Institute of Natural Science.

Hamilton .....Hamilton Association.

Ottawa .....Geological and Natural History Survey of Canada (A. R. C. Selwyn, F.G.S., Director, Museum, Sussex Street, Ottawa).

M'Gill College (Principal, Sir J. W. Dawson, F.G.S.).

Editor of Canadian Mining Review.

St. John's, N. B...Natural History Society of New Brunswick.

Toronto .....Canadian Institute.

VI.—India.

Calcutta .....Geological Survey of India.

VII.—United States.

Boston, U.S. ....Free Library.

Chapel Hill, North Carolina, U.S... The Elisha Mitchell Scientific Society.

Columbus, U.S....Ohio, Geological Survey of (Professor Edward Orton, State Geologist).

Denver .....Colorado Scientific Society, Denver, Colorado.

Indiana, U.S.....Department of Geology and Natural History.

Illinois, U.S.....Illinois Mining Institute, Springfield, Ill.
Field Columbian Museum, Chicago.

Indianopolis, U.S...Professor John Collett, State Geologist

Michigan, U.S. ..Michigan Mining School, Houghton.

Newhaven, U.S...Professor O. C. Marsh, F.G.S.

New York, U.S...American Institute of Mining Engineers (R. W. Raymond, Box 223, New York City).

New York .....American Museum of Natural History, Central Park.

Philadelphia, U.S...Academy of Natural Sciences.
Franklin Institute.
Pennsylvania Geological Survey.
American Philosophical Society, 104, S. Fifth Street.

Shenandoah, Pa...Editor of the Colliery Engineer.

Washington, U.S...Department of the Interior. U.S. Geological Survey.
Smithsonian Institution.

Wisconsin, U.S...Wisconsin Academy of Science, Arts, and Letters, Madison.

Wyoming, U.S...Historical and Geological Society.

VIII.—Foreign Societies.

Berlin.....Deutsche Geologische Gesellschaft.
Gesellschaft fur Erdkunde. Zimmerstrasse, 90, Berlin, S.W., 12.

Brussels .....Société Royale Malacologique de Belgique.

Buenos Ayres....Officiana Nacional de Commercie.

Christiania.....Royal University of Norway.

Dresden .....Naturwissenschaftliche Gessellschaft Isis.

Halle, A.S. ....Verein für Erdkunde.
Die Kaiserliche Leopold. Carol. Deutsche Akademie der Naturforscher.

Helsingfors.....Geological Commission of Finland. Dr. J. J. Sederholm.

Kazan, Russia ..La Société des Naturalistes de l'Université de Kazan.

Kieff, Russia ....La Société des Naturalistes.

Lausanne (*Suisse*).Société Vaudoise des Sciences Naturelles.

Löcse, Hungary..Sociéte Hongroise de Carpathes (Centrale in Leutschau).

Lille .....Société Geologique du Nord.

Naples .....Royal Academy of Sciences, Bibliothèque de l'Université de Naples.

Paris .....Société Géologique de France, 7, Rue des Grands-Augustins.

Pisa .....Società Toscana di Scienze Naturali, Museo di Storia-Naturale.

Rio de Janeiro ..Museo Nacional.

Rome .....Reale Academia dei Lincei.

St. Petersburg ..Académie Impériale des Sciences.
Institut des Mines. Comité Géologique.

Turin .....Académie Royale des Sciences.

IX.—Scientific Journals, &c.

Iron and Coal Trades Review, 342, Strand, W.C.

Mining Journal, 18, Finch Lane.

Colliery Guardian, 49, Essex Street, Strand, London.

Science and Art of Mining, 27, Wallgate, Wigan.

PAST PRESIDENTS OF THE SOCIETY.

Year of Election.	
1838-39-40	Egerton, The Rt. Hon. Francis, M.P.
1841-2-3, 49-50-1	Heywood, James, F.R.S., F.G.S.
1843-4-5, 55-6-7	Egerton, Sir Philip de Malpas Grey, Bart., M.P.
1845-46-47	Moseley, Sir Oswald, Bart.
1847-48-49	Thicknesse, Ralph, M.P., Wigan.
1851-52-53	Black, James, M.D., F.G.S.
1853-54-55	Ormerod, G. W., M.A., F.G.S.
1857-8-9, 65-6-7	Binney, E. W., F.R.S., F.G.S.
1859-60-61	Kay-Shuttleworth, Sir, J.P., Bart., M.P.
1861-3, 77-8, 87-8	Dickinson, Joseph, F.G.S.
1863-64-65	Knowles, Andrew.
1867-8-9, 84-5	Greenwell, G. C., F.G.S., M.Inst.C.E.
1869-70-1, 82-3	Aitken, John, F.G.S.
1871-2-3, 88-9	Knowles, John, M.Inst.C.E., J.P.
1873-74	Knowles, Thomas, M.P.
1874-5, 6-7, 86-7	Dawkins, Professor W. Boyd, F.R.S., F.G.S.
1875-76	Smith, R. Clifford, F.G.S.
1878-79	Forbes, John Edward, F.G.S.
1879-80	Lindsay, Lord, F.R.S.
1880-81	Kay-Shuttleworth, Sir Ughtred J., Bart.
1881-82	Gilroy, George, M.Inst.C.E.
1883-84	Pilkington, Edward, J.P.
1885-86	Ormerod, Henry Mere, F.G.S.
1889-90	Hall, Henry, H.M.I.M.
1890-91	Burrows, John S., F.G.S.
1891-92	Tonge, James, F.G.S., Assoc.M.Inst.C.E.
1892-93	Peace, Maskell William, F.G.S.
1893-94	Saint, William, H.M.I.M.
1894-95	Watts, William, F.G.S.
1895-96	Winstanley, Robert, C.E.
1896-97	Stirrup, Mark, F.G.S.

LIST OF MEMBERS.

OCTOBER, 1897.

The Names of Honorary Members are printed in *Italics*.

* Members who have compounded for the Annual Subscription.

Year of Election.	
1874	*Agassiz, Alexander*, Cambridge, Massachussetts, U.S.A.
1884	Ainsworth, John, Colliery Offices, Walkden, Bolton.
1884	Aldred James, Bull Hotel, Radcliffe.
1897	Allen, Edward, M.E., Willow Bank, Peel Causeway, Bowdon, Cheshire.
1879	Arrandale, John Thomas, 82, Brook Street, Wigan.
1893	Ashworth, John, C.E., 8, King Street, Manchester.
1878	Ashworth, Thomas, 42, Deansgate, Manchester.
1877	Atherton, James, 13, Mawdsley Street, Bolton. *Member of Council.*
1895	Atherton, H. Stanley, Land and Mine Surveyor, 13, Mawdsley Street, Bolton.
1878	Atkinson, W. N., H.M. Inspector of Mines, Barlaston, Stoke-on-Trent, *Vice-President.*
1881	Aubrey, Richard Charles, Tiviot Dale, Cambridge road, Churchtown, Southport.
1897	Baker, Godfrey, Pendlebury, Manchester.
1893	Bancroft, Robert Ed., 8, St. James's Square, Manchester.
1894	Banks, William, Electrician, Bolton.
1894	Barlow, Sam. C., Rock Cottage, Roman Road, Tiviot Dale, Stockport.
1895	Barnes, J., F.G.S., 1, Trafalgar Street, Lower Broughton. *Member of Council.*
1875	Barrett, W. S., New Hall, 41, Old Hall Street, Liverpool.
1880	Barton, Richard.

Year of Election.	
1891	*Bell Thomas*, J.P., Valley Road, Scarborough.
1881	Black, W. G., F.R.C.S. Ed., F.G.S. Ed., 2, George's Square, Edinburgh.
1889	Bolton, Edgar O., Burnley Collieries, Burnley. *Member of Council.*
1867	Bolton, H. H., Newchurch, near Manchester.
1880	Bolton, H. H., jun., The Collieries, Accrington.
1887	Boole, George, Rainford Colliery, near St. Helens.
1894	Borrows, William, Engineer, Providence Foundry, St. Helens.
1878	Bradford, The Right Hon. the Earl of, Bradford Estate Office, Bolton (G. R. Carter, Esq., Agent).
1894	Bradshaw, Edward, Great Lever Collieries, Bolton.
1886	Bramall, Henry, M.Inst.C.E., Shade House, Pendlebury, Manchester.
1878	Bramall, Ernest E., Pendlebury Collieries, near Manchester.
1897	Brooks, The Hon. William, J.P., Crawshaw Hall, Rawtenstall, Manchester.
1878	Brocklehurst, Thomas, Rumworth Colliery, Dean, Bolton.
1877	*Broeck, Ernest Van den*, 39, Place de l'Industrie, Brussels.
1877	*Brongniart, Charles*, F.E.S., 9, Rue Linné, Paris.
1881	Bryham, William, Douglas Bank Colliery, Wigan.
1878	Burrows, John S., F.G.S., Green Hall, Atherton, near Manchester. *Past-President.*
1882	Caldwell, George, Moss Hall Collieries, Wigan. *Member of Council.*
1884	Campbell, H. H., Surveyor, Hardshaw Street, St. Helens.
1887	Campbell, W. M., Sutton Heath Collieries, St. Helens.
1881	Clark, Christopher F., Park Lane Collieries, Wigan.
1882	Clark, George, Mining Engineer, Newton-le-Willows.
1894	Clark, Robert, 42, Deansgate, Manchester.
1889	Clay, Richard, Dukinfield Coal Company, Dukinfield.
1886	Clifford, William, 610, Lewis Block, Pittsburg, Pa., U.S.A.
1894	Cole, Robert H., Endon, Stoke-on-Trent.

Year of Election.	
1895	Coope, Samuel, Land and Mine Surveyor, Farnworth, Bolton.
1878	Cowburn, Henry, 253, West Leigh Lane, West Leigh, near Manchester.
1883	Crankshaw, Joseph, Montcliffe, Horwich. *Member of Council.*
1879	Crawford and Balcarres, The Right Hon. the Earl of, Haigh Hall, Wigan. *Past-President.*
1862	Cross, John, 77, King Street, Manchester.
1869	Dawkins, Professor W. Boyd, M.A., F.R.S., F.G.S., F.S.A., The Owens College, Manchester. *Past-President.*
1890	Dean, John, Wigan Coal and Iron Co., Limited, Wigan.
1877	*De Rance, C.E.*, F.G.S., Stoke Road, Shelton, Stoke-on-Trent, Stafford
1856	Dickinson, Joseph, F.G.S., South Bank, Pendleton. *Past-President.*
1889	Dobbs, Joseph, Coolbawn, Castlecomer, Co. Kilkenny.
1884	Else, George, Altham Colliery, Whalley Road, Accrington.
1878	Ellesmere, The Right Hon. the Earl of Worsley.
1895	Ellis, Thomas Ratcliffe, Solicitor, King Street, Wigan.
1894	Evans, Robert, Mining Engineer, Royton, Oldham.
1880	Fairclough, William, Leigh, near Manchester.
1891	Fallows, William, Arbury Road, Nuneaton.
1891	Finch, John, Hampstead Colliery, Great Barr, Birmingham.
1891	Fletcher, Arthur, Outwood Collieries, Radcliffe.
1896	Fletcher, Leonard R., Atherton Collieries, Atherton, Manchester.
1896	Fletcher, Norman, The Hollins, Bolton.
1868	Fletcher, Thomas, Haulgh, Bolton.
1889	Foster, John W., Whitburn Colliery, South Shields.

Year of Election.	
1873	Garforth, W. E., F.G.S., Halesfield, Normanton.
1893	Garside, Edward, B.Sc., 6, Chester Square, Ashton-under-Lyne.
1884	Garside, Samson, Denton and Haughton Collieries, Denton. *Vice-President.*
1889	Gascoyne, Rowland, Blackburn Collieries, Broxburg, near Johannesburg, South African Republic.
1874	*Geikie, Sir Archibald,* D.Sc., LL.D., F.R.S., Geological Survey. Jermyn Street, London, S.W.
1892	Gerrard, John, H.M. Inspector of Mines, Worsley. *Vice-President.*
1882	Glover, B. B., 41A, Victoria Buildings, Manchester.
1892	Grant, Frederick John, Bank Field, Burnley.
1890	Green, John, Ty'n Twll Colliery, near Mold, Flintshire.
1882	Greenhalgh, Robert, Engineer, Atherton, near Manchester.
1883	Greensmith, T., Topcliffe House, Tingley, near Wakefield.
1863	Greenwell, G. C., F.G.S., M.I.C.E., Elm Tree Lodge, Duffield, Derby. *Past-President.*
1874	Greenwell, G. C., jun., F.G.S., Poynton, near Stockport.
1879	Greenwood, John, 63, Albert Road, Southport.
1892	Gregson, G. Ernest, 11, Chapel Street, Preston.
1890	Gresley, W. S., F.G.S., 348, West 8th Street, Erie, Pennsylvania, U.S.A.
1877	Grundy, H. T., Colliery Surveyor, Radcliffe.
1888	Grundy, James, Inspector of Mines in India, 27, Chowringhee Road, Calcutta, India.
1881	Hall, Henry, H.M. Inspector of Mines, Rainhill, Prescot. *Past-President.*
1887	Hallas, George H., Mining Engineer, Huyton, near Liverpool.
1892	Halliwell, James, Duxbury Park Colliery, Chorley, Lancashire.

Year of Election.	
1877	Handsley, Robert, Burnley Colliery Offices, Burnley.
1897	Harris, George E., M.E., Assam Railway and Trading Co., Limited, Margerita, Assam, India.
1894	Harrison, George B., Inspector of Mines, 278, Brooklands Terrace, Worsley Road, Swinton, Manchester. *Member of Council.*
1892	*Haworth, Denis, Beech House, Blackburn Road, Accrington.
1894	Hayward, John, Ladyshore Colliery, Little Lever, Bolton.
1893	Heyes, William A., Electrician, 5, Dawson Street, Bolton.
1838	*Heywood, James, F.R.S., F.G.S., 36, Kensington Palace Gardens, London, W. *Past-President.*
1889	Higson, Charles H., The Park Collieries, Wigan.
1876	Higson, John, F.G.S., 18, Booth Street, Manchester.
1897	Hobson, Bernard, M.Sc., F.G.S., The Owens College, Manchester.
1877	Holding, William, Cossall Colliery, near Nottingham.
1878	Hollingworth, George H., F.G.S., 12, King Street, Manchester, *Hon. Auditor.*
1895	Holroyd, W. F., F.G.S., River Cottage, Lower Broughton. *Member of Council.*
1884	Howat, Andrew.
1897	Howsin, Evelin G. Huntroyde, Estate Office, Padiham.
1884	Hughes, Owen, The Grange, Coppull, near Chorley.
1874	*Hull, Professor Edward,* M.A., F.R.S., 20, Arundel Gardens, Notting Hill, London, W.
1896	Humphrey, Robert, F.S.A. (Scot.), 12, King Street, Manchester.
1894	Hutchinson, John William, Bamfurlong Collieries, Wigan
1889	Iles, John, 76, Church Street, South Shore, Blackpool.
1887	Jackson, Andrew, Manager, Collins Green and Bold Collieries, Newton-le-Willows.

Year of Election.	
1878	Jackson, Charles G., Anderton Hall, near Chorley.
1887	James, J. Stanley, Caswell Bay, near Swansea.
1883	Jobling, Albert, Spring Wood House, Burnley.
1883	Jobling, Henry, Spring Wood House, Burnley.
1884	Jobling, John, Barcroft, Cliviger, Burnley.
1890	Johnson, Alfred E., Abram Colliery, Wigan.
1882	Johnson, William, Abram Colliery, Wigan.
1897	Keirby, John E., Swinton, Manchester.
1894	Kelsall, James E., High Bank, Tonge, Bolton.
1893	Kendrick, James P., 8, St. James's Square, Manchester.
1879	*Kinahan, G. H.*, M.R.I.A., Woodlands, Fairview, Co. Dublin.
1889	Knowles, James. Pearson, Knowles & Co., Wigan.
1889	Knowles, John, Brynn Mount, Westwood, Lower Ince, Wigan.
1887	*Knowles, Lees, M.A., LL.M., M.P., Westwood, Pendlebury.
1886	Knowles, Robert, Ednaston Lodge, near Derby.
1893	Laithwaite, V. W., Surveyor's Office, Turton, Bolton.
1890	Law, J. Illingworth, Waterfoot, near Manchester.
1884	Leech, A. H., Brinson Hall Colliery Wigan.
1897	Lees, Frederick, Alkrington Mount, Middleton.
1894	Lindsey, Charles R., B.Sc., Chemical Manufacturer, 509, Edge Lane, Droylsden, Manchester. *Member of Council.*
1862	Livesey, Clegg, Bradford Colliery, Manchester. *Hon. Treasurer.*
1877	Livesey, Thomas, Bradford Colliery, Manchester.
1896	Lomax, Charles J., C.E., 19, Grosvenor Chambers, Manchester.
1877	Lord, James, Hill House, Rochdale.

Year of Election.	
1897	McCallam, Theo. S., C.E., 4, Chapel Walks, Manchester.
1897	Makepeace, H. R., H.M. Inspector of Mines, Newcastle-under-Lyme.
1891	Marshall, Herbert S., The Larches, Wigan.
1893	Matthews, E. L., Mechanical Engineer, &c., Imperial Iron Works, West Gorton, Manchester.
1892	Mathews, D. H. F., H.M. Inspector of Mines, Hoole, Chester. *Member of Council.*
1896	Matthews, Thomas, Artesian Engineer, West Gorton, Manchester.
1881	Mc.Alpine, G. W., Parkside, Accrington.
1890	McGeevor, James, Garswood Hall Colliery, Wigan.
1873	*Martin, Joseph S.*, H.M. Inspector of Mines, Durdham Park, Clifton, Bristol.
1885	Mawson, Robert Bryham, Sovereign Colliery, Westleigh, Leigh, near Manchester.
1890	Mercier, Maunsell, 5, Deansgate, Manchester.
1892	Miller, Arthur, Broad Oak, Hurst, Ashton-under-Lyne.
1892	Millington, W. W., Hardman House, Hollinwood, Oldham.
1892	Mills, David, Bradford Street, Farnworth.
1895	Mitton, A. Dury, Oakwood, Walkden, Bolton.
1876	Moore, Alfred, C.E., Queen's Chambers, No. 2, Ridgefield, Manchester.
1892	Morris, Moses, Swan Lane, Hindley, Wigan.
1895	Mort, Arthur, 345, Ashton New Road, Clayton, Manchester.
1874	*Morton, G. H.*, F.G.S., 209, Edge Lane, Liverpool.
1888	Munro, Donald, Fairfield, near Manchester.
1878	Nall, Simon, Newbold, Rochdale.
1897	Noar, L. Lamb, The Grove, Lymm.

Year of Election.	
1888	Oliver, Samuel A., King Street, Wigan.
1891	Orchard, Albert J. A., Atherton Colliery, Atherton, near Manchester.
1838	*Ormerod, H. M.*, F.G.S., 5, Clarence Street, Manchester. *Past-President.*
1876	Peace, George, Monton Grange, Eccles. *Member of Council.*
1883	Peace, George Henry, M.Inst.C.E., Monton Grange, Eccles.
1897	Pearce, Charles H., Surveyor, Hulton Collieries, near Bolton.
1884	Piggott, I., Carlton Villa, Lathom, near Ormskirk.
1879	Pilkington, Charles, The Headlands, Prestwich, Manchester.
1873	Pilkington, Edward, J.P., Clifton Collieries, near Manchester. *Past-President.*
1877	Place, W. H., Hoddleston Collieries, Darwen.
1887	Platt, Samuel Sydney, M.Inst.C.E., F.G.S., 14, King Street South, Rochdale. *Vice-President.*
1891	Prestwich, Joseph, Irwell Park, Eccles.
1895	Purdy, Richard, Moston Colliery, Newton Heath, Manchester.
1897	Reid, Alexander, Dover Collieries, Dover.
1897	Richardson, Isaiah, Blainscough Collieries, Coppull, near Chorley.
1860	Ridyard, John, F.G.S., Hilton Bank, Little Hulton, Bolton. *President.*
1893	Rigby, John, Highfield, Winsford, Cheshire.
1889	Robinson, John, Haydock Collieries, St. Helens.
1890	Robson, Thomas, Wigan and Whiston Colliery Co., Prescot.
1892	Roscoe, George, Peel Hall Collieries, Little Hulton, Bolton.

Year of Election.	
1895	Rothwell, Samuel, Silverwell Street, Bolton.
1895	Ryans, Joseph, Colliery Manager, Arigna Mines, Carrick-on-Shannon.
1887	Saint, William, H.M. Inspector of Mines, Kersal Bank, Higher Broughton, Manchester. *Past-President. Hon. Secretary.*
1888	Scarborough, George Edward, Colliery Manager. New Town and Meadows Collieries, Wigan.
1887	Scott, Frederick W., Atlas Works, Reddish, near Stockport.
1889	Scott, William B., 133, Manchester Old Road, Middleton.
1891	Scowcroft, Thomas, Redthorpe, Tonge, Bolton. *Member of Council.*
1882	Settle, Joel, The Hill, Alsagar, Stoke-on-Trent.
1878	Settle, Miles, Snow Hill, Darcy Lever, near Bolton.
1889	Settle, William, Snow Hill, Darcy Lever, near Bolton.
1884	Shaw, David, Norbury Moor, near Stockport.
1887	Shuttleworth, Sir Ughtred J. Kay, Bart., Gawthorpe Hall, Burnley. *Past-President.*
1884	*Simpson, W. W., Winkley, near Whalley, Blackburn.
1894	Slee, John, Engineer, Earlestown.
1864	*Smethurst, William, F.G.S.
1893	Smith, Henry.
1881	Smith, John, Bickershaw Collieries, West Leigh, near Manchester.
1873	*Smith, R. Clifford, F.G.S., Ashford Hall, Bakewell. *Past-President.*
1888	Smith, Sydney Arthur, 1, Princess Street, Albert Square, Manchester.

Year of Election.	
1881	Southworth, Thomas, Hindley Green Collieries, Wigan.
1886	Speakman, Harry, Bedford Collieries, Leigh, Lancashire.
1881	Squire, J. B., Assoc.M.Inst.C.E., The Wynd, Streatham Park, London, S.W.
1890	Stafford, Thomas, 1, Lea Road, Heaton Chapel, Stockport.
	Stechert, G. E., 2, Star Yard, Carey Street, London, W.C.
1897	Scholes, Thomas, 25, Crossley Street, Longsight, Oldham.
1880	Stirrup, Mark, F.G.S., High Thorn, Stamford Road, Bowdon. *Past-President.*
1882	Stopford, T. R., Ashton's Green Collieries, St. Helens, Lancashire.
1891	Sutcliffe, Richard, Horbury, near Wakefield.
1889	Taylor, William, 6, Bull Hill, Darwen.
1892	Thom, John, Canal Works, Patricroft.
1893	Thompson, F. W., 5, Wood Street, Bolton.
1892	Thompson, James, Westhoughton, Bolton.
1894	Thompson, John G., Mining Engineer, Bamfurlong, Wigan.
1893	Thompson, Peter 40, Hardman Street, Hollinwood, Oldham.
1893	Timmins, Arthur, A.M.I.C.E., F.G.S., Bridgewater Foundry, Runcorn.
1891	Tonge, Alfred J., Hulton Colliery, near Bolton.
1873	Tonge, James, F.G.S., Assoc.M.Inst. C.E., Albany Chambers, Mawdsley Street, Bolton. *Past-President.*
1886	*Trafford, Sir Humphrey Francis de, Bart., 18, Arlington Street, London, W.
1895	Travers, T. W., Mining Engineer, Church Street, Leigh, Lancashire.

Year of Election.	
1892	Turner, William, Wigan Junction Colliery, Abram, near Wigan.
1896	Turner, William, Sherdley Colleries, St. Helens.
1876	Unsworth, John, Scott Lane Colleries, Wigan.
1887	Walkden, Richard, Colliery Manager, 26, Watery Lane Terrace, Springvale, Darwen.
1882	Walker, T. A., Pagefield Iron Works, Wigan.
1882	Wall, Henry, Rowbottom Square, Wallgate, Wigan.
1893	Wallwork, Jesse, Shakerley Collieries, Tyldesley, near Manchester.
1888	*Walmsley, Oswald, 2, Stone Buildings, Lincoln's Inn, London.
1879	Walshaw, John, Astley and Tyldesley Collieries, Tyldesley.
1892	Warburton, Thomas, 10, Bolton Road, Moses Gate, Bolton.
1892	Ward, Alexander Haustonne, Ranigunj, Bengal, India.
1885	Ward, Thomas, J.P., F.G.S., Brookfield House, Northwich. *Member of Council.*
1880	Watts, William, F.G.S., 34, Wilkinson Street, Sheffield. *Past-President.*
1878	Wells, Samuel B., Mining Engineer, Calcutta.
1877	West, T. E., Union Street, Oldham.
1897	Whewell, John, Jun., Land and Mine Surveyor, Sharples, Bolton.
1890	*Whitaker, William,* B.A., F.R.S., F.G.S., Freda, Camden Road, Croydon.
1891	Whitehead, J. J., Bracklyn, Steven Street, Stretford, Manchester.

Year of Election.	
1867	*Wild, George*, Albert Street, Bardsley, Ashton-under-Lyne.
1880	Williams, Sir E. Leader, M.Inst.,C.E., Manchester Ship Canal Company, King Street, Manchester.
1897	Winstanley, George H., F.G.S., 42, Deansgate, Manchester. *Hon. Secretary.*
1876	Winstanley, Robert, C.E., 42, Deansgate, Manchester. *Past-President.*
1886	*Wood, Guy.
1876	Woodward, H. A., Oakwood, Clifton, near Manchester. *Hon. Auditor.*
1895	Wordsworth, T. H., New Moss Colliery, Audenshaw, near Manchester.

Members are requested to communicate to the Hon. Secretaries all changes of address, also any corrections or omissions in the list.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XIII. VOL. XXV. SESSION 1897-98.

The ORDINARY MEETING of the Members was held on Tuesday, November 9th, 1897, at the Society's Rooms, Queen's Chambers, 5, John Dalton Street, Manchester.

The President, Mr. JOHN RIDYARD, F.G.S., in the Chair.

The PRESIDENT (who now took the chair for the first time since his election) thanked the members for the honour they had done him. Before he delivered his address, he said he would ask the meeting to dispose of one or two matters which were to be brought forward.

THE LATE MR. JAMES HEYWOOD, F.R.S.

Mr. MARK STIRRUP said: Since our last meeting you will all have been made aware of the death of Mr. James Heywood, F.R.S., whose obituary has been in most of the papers both in Manchester and in London; and it will also be within your knowledge that Mr. Heywood was one of the founders of this Society and also one of its early Presidents; in fact, he succeeded Lord Francis Egerton, the first President. He was, moreover, one of the most liberal benefactors of the Society in its early days. In the short sketch of this

Society's early history, which I presented last year, information is given showing how much we are indebted to him. I desire that the Society, on its first meeting since the announcement of his death, should pass a vote of condolence with his family or representatives, and state how deeply we are touched at his loss. I move that such a vote be passed.

Mr. JOSEPH DICKINSON: I beg to second the motion. Mr. Stirrup might have added that the late Mr. Heywood was one of the first Vice-Presidents of the Society, and that he was the donor—or one of two donors—of that very valuable specimen of the Ichthyosaurus which our Society had put into shape by Mr. Waterhouse Hawkins, and which now adorns the Museum at Owens College.

The motion was passed unanimously.

Mr. DICKINSON: Another member of this Society who favoured us with his attendance a very few meetings ago, Mr. P. W. Pickup, has also passed away since our last meeting. His father was an old member of this Society, and so long back as 1858 he presented us with some very fine specimens of fossils from one of the mines which belonged to him in partnership with the present Lord Crawshaw. Mr. Peter Wright Pickup himself also sent us a full section of one of the seams which he was working at his colliery at Rishton. Both he and his father were benefactors of this Society as donors of fossils, &c. I move, therefore, that a vote of condolence be sent to the family of the late Mr. Pickup.

Mr. STIRRUP: I have much pleasure in seconding Mr. Dickinson's motion, because I know Mr. Pickup contributed a numerous collection of fossils some little time ago, and the section of which Mr. Dickinson speaks is now in the Museum at Owens College, and is a most instructive one.

ELECTION OF AN HONORARY MEMBER.

The PRESIDENT: We will now proceed to the election of Mr. George Wild as an honorary member, of which notice appears in the agenda. In regard to this, I may say the Honorary Secretaries have received a letter from Professor Boyd Dawkins, who is unable to be present with us to-day, in which he cordially supports the proposal.

A ballot of the members was then taken, and Mr. Wild was declared unanimously elected an honorary member of the Society.

Mr. DICKINSON said: In connection with this election of Mr. George Wild as an honorary member of this Society, I desire to mention that a few days ago, when looking over some of the old lists of members to see how many now survive of those who formerly sustained the Society, I found that in the 1860 list, under the old rules, the name of the same Mr. George Wild, then manager of Fulledge Colliery, Burnley, appears as a corresponding member, entitling him to the same privileges as an honorary member. How this distinction slipped away from the knowledge of the Society I do not know. There must have been laxity somewhere. It is a most regretable oversight. The only explanation I can imagine is that as the distinguishing mark was simply a prefixed symbol in the list it became inadvertently overlooked in succeeding prints. He might, under the privilege generally considered proper, have once mentioned the oversight to some person in authority and afforded opportunity for rectification, but apparently he did not do so, and the omission continued. Fortunately his merit as a practical and scientific geologist, as well as an experienced colliery manager, again brings him to the front, and warns us to be careful in future. Let us hope that he will pardon the inadvertancy, and continue to favour the Society with his knowledge as before, during about forty years.

NEW ORDINARY MEMBERS.

The following gentlemen were balloted for and duly elected Ordinary Members of the Society:—

Mr. F. F. Bennett, M.I.E.E., 13, Victoria Buildings, Manchester.

Mr. J. G. Guy, Manager, Hindley Field Collieries, Abram, Wigan.

Mr. James Keen, Hindley Green, near Wigan.

Mr. William Nelson, jun., Manager, Clifton and Kersley Collieries, Clifton, near Manchester.

Mr. James Tickle, Manager, Abram Collieries, Bickershaw, Wigan.

FOSSIL FISHES FROM IRELAND.

Mr. Dickinson called attention to a collection of fossils from the Jarrow Collieries, County Kilkenny, sent on loan by Mr. Saint, one of the honorary secretaries. Mr. Dickinson said:—I have been requested by Mr. Saint, who is prevented by official duties from attending this meeting, to say that these fossil fish now exhibited from Jarrow Colliery, Castlecomer, County Kilkenny, were given to him some time ago, and that he has been waiting an opportunity of showing them to the members. He asks me, as I know the seam of coal and the position in which the fossils are found, if I will give the meeting any information I may think necessary thereon. It will be remembered that at a recent meeting Mr. Sutcliffe gave us some particulars on the subject. And I may add that a fortnight ago when talking the matter over with Mr. Joseph Dobbs, the owner of the colliery, I

asked him to give us a short paper with a detailed section of the strata describing the exact positions, and I think he will do so. The fossils are remarkably well preserved, and I hope that, as through my instrumentality Mr. Dobbs formerly sent some similar fossils to the Manchester Museum at the Owens College, Mr. Saint, if he has not already promised these, will kindly remember that there is also the well arranged Salford Museum at Peel Park, where some of the specimens would be welcomed.

The specimens, as described by Mr. Sutcliffe (Mr. Dickinson added) were chiefly in the shale, below the coal, but some of these fossil fishes were actually embedded in the coal, and were quite perfect.

Mr. Stirrup: I should like to say a word with regard to the ultimate destination of these fossils. I think it would be a great pity indeed if they crossed the Irwell. I think, as we have some fossil fishes and reptiles from the same Coal Measures at Owens College, these also should go there, and we should not divide what should be a really good collection by sending them to Salford. I may say in this connection, that not unfrequently strangers and foreigners, visiting Manchester, go to the Owens College Museum for information about Manchester geology, and although the fossils now exhibited are from Ireland, and have nothing to do, strictly speaking, with Manchester geology, yet we have got, by means of Mr. Dickinson's influence with the owners of this colliery, some of those, what I would call, rather precious fossils, which have been already sent there; and I think the members will rather wish that these specimens should be added, in order that the collection from this peculiar coalfield may be a representative one. I should be glad also to know that Mr. Dobbs has been able to make something out as to the exact horizon from which they were taken, because some years ago the gentlemen belonging to the Irish Geo-

logical Survey seemed to be rather in a fog upon that point. It would be satisfactory to know if Mr. Dobbs has, by later investigations, been able to decide as to whether they belong to the Upper or the Middle Coal, or what is their true stratigraphic position.

Mr. Dickinson: Mr. Dobbs, as you will know, is a member of our Society.

Mr. Stirrup: I am aware of that.

Mr. Dickinson: In talking the matter over with him he acquiesced in my suggestion that he should give a short paper to the Society.

Mr. Stirrup: I hope the specimens will be reserved for the College Museum.

Mr. Dickinson: Perhaps there may be a division of them. Some may go to the Salford Museum; but I quite agree that the best of them should go to the College.

Mr. Herbert Bolton: I had the task of arranging the geological collections of the Salford Museum, and had the greatest possible difficulty in finding room for the specimens they have; indeed, a large number of minerals and fossils are in the store rooms, which they cannot find exhibition room for. At the express desire of the Museum Sub-Committee, which had that matter of re-arranging the geological collections in hand, I restricted myself to exhibiting specimens dealing entirely with Lancashire geology; therefore if you give these specimens to the Salford Museum they will either have to obtain new cases—and I do not know where they would put them—or they will have to extend their plan, and work in other divisions of the Coal Measures besides those of Lancashire.

Further discussion was postponed.

THE PRESIDENT'S INAUGURAL ADDRESS.

The PRESIDENT then delivered his address:—

THE UTILITY OF ASSOCIATION FOR THE PROMOTION OF SCIENCE, AND OF ITS APPLICATIONS.

By Mr. JOHN RIDYARD, F.G.S.

My first duty on assuming the honourable and distinguished position of President of the Manchester Geological Society, to which your choice has elevated me, must be to offer you my warmest thanks for this great honour, and to assure you that I will endeavour to discharge the duties of the office with a faithful and conscientious regard, seeking always to maintain the interests, and to cherish the privileges which have so long marked the history of the Society. I trust it will not be found that I have presumed too fondly, in the belief that an earnest wish to serve the Society is a sufficient guarantee for the performance of the duties pertaining to its President; but whatever measure of short-coming may be imputed to me during my tenure of the chair, I would beg you, at least, to credit me with the best intentions to observe its prerogatives faithfully and strictly. I cannot hope to leave behind me a record in any way approaching that of the many eminent observers and students who have been my predecessors in this chair, but, none the less, while I can receive and deserve the sympathetic support of my colleagues on the executive, and of the general body of my fellow-members, I need not hesitate to expect that consideration and assistance in the performance of duty, which is ever accorded to the efforts of disinterested workers in a common cause. It is in this spirit of confidence in the leniency which will be extended towards my attempt, that I have essayed to

deliver the address which it is customary for your President to inaugurate his term of office with; and in deciding on the choice of a subject suitable to the occasion I have naturally been a good deal embarrassed when looking back on the array of distinguished names of past Presidents who have from time to time instructed and delighted us with their handling of subjects, by the study and elucidation of which they have not only provided this Society with a fund of information of the most lasting and useful description, but have also influenced the world at large, and conferred lasting benefits on humanity. There is so much that is stirring in the history of the Society, from its inception and earliest developments, nearly sixty years ago, right up to the present time; there have been so many great and worthily eminent men, leaders in the world of science, who have been associated with it in all the phases of its growth and increasing usefulness, that those like myself, whose only claim to consideration is an earnest desire to do the little that we can do, well, must needs be somewhat oppressed when called upon to tread in the honoured steps of pioneers of progress such as they were. We know, however,—for humility towards others is ever an attribute of true greatness,—that these themselves would have gladly welcomed the humblest among their followers, and would have accorded to their labours a full acceptance of their worth, so long as these labours were the honest product of self-sacrificing endeavour, and were animated by the love of truth, through which alone enduring conquests in the realm of nature can be won by man. Notwithstanding, therefore, that my title to address you cannot at all compare with that of so many who have preceded me in the Presidential office, I have ventured to accept the task the honour carries with it, feeling that by so doing I may best fulfil the wishes and intentions of the founders and supporters of our Society.

It would be useless for me to seek to engage your attention on any specific subject connected with the immediate study denoted by the title of our Society, for, as a practical geologist, the information at my command has no special value; nor is it other in nature than that which is the regular working equipment of those whose profession is that of engineering in the field rather than academic in the study. It has occurred to me that it might have been of use to devote this paper to the discussion of one or other of the many points of interest in connection with mining enterprise, in which the scientific geologist joins hands with the practical engineer in the endeavour to solve problems to which the attention of both must needs be turned for their successful unravelling. But here again I could scarcely hope to do more than reiterate, more or less, the conclusions enunciated in this place, within comparatively recent time, by my predecessors. And so, thinking thus, I have resolved for a time to leave aside altogether a reference to any particular topic in the field either of speculative Geology, or of the immediate applications of its teachings; and to crave your indulgence while, instead, I dwell, briefly, on the influence exercised by the voluntary association of minds engaged in a common study on the progress of knowledge.

In this year of Jubilee rejoicings we have heard from the mouths of orators of every degree of eloquence, repeated assurances of the marvellous advances which have been made within the Victorian era in every department of science and in the applications of scientific principles to the requirements of the manufacturing industries, as well as to the needs of civilised life. It has been over and over again pointed out, in the speeches of orators, political, social and general, that the stimulus through the agency of which these great and oftentimes revolutionary changes have been brought about, appeared to originate, or at any rate to grow in strength, under the influence of a spirit

which developed in intensity coincidently with the political and social activity that were the outcome of a movement culminating in an urgent demand for reform in the early thirties. This may be regarded as the beginning of a popular awakening to, and appreciation of the truth that lethargy and diffidence should at length give way to energetic endeavour, and a striving after better things. Much, undoubtedly in the way of advance, had been accomplished in the earlier years of the nineteenth century. A few earnest workers had continued and extended the labours of research and experiment inaugurated by those who had grappled with the secrets of nature before them; and by slow degrees the path to fuller information was being cleared of the obstacles which hindered onward progress. But, the workers were few, though eager and enthusiastic; and, what was more especially the cause of delay and disappointment, there was little of that combined action among them, and of that intercommunication of thought, which constitute so marked a feature of the labours that are prosecuted to-day in this connection. To some extent this may be explained as resulting from the difficulties encountered by all but the wealthiest sections of society in moving about from place to place. Not only was such locomotion then a very expensive undertaking, but it entailed such sacrifice of time and convenience as might not be within the reach of many, who, as thinkers and workers, would have derived inestimable benefits by free exchange of ideas between themselves, and by united discussion of subjects in which they shared a common interest. We are justified in believing that in every phase of civilisation, even in the darkest dawn of its commencement, there have been individuals endowed with qualities of mind transcending those of their fellows at the time; indeed that this should be the case is an absolutely essential condition of human advancement, and is as truly happening at the present day,

as it has happened in the past. To such superior intelligence, in all ages, it is due that their posterity enjoyed the fruits of discovery; and also is it true, that improvements in the capacity for living have enabled mankind from age to age, so to enlarge the sphere of his intellectual activities as to make further and further conquests over the unknown and the obscure. But so long as the opportunities for communicating these discoveries to others were confined to such occasional means of transference as the pre-steam means of locomotion afforded, so long was it impossible that the enthusiasm of research should be stimulated in the many through the work of the few in whom the sacred fire of genius had its altar, and who by the personal magnetism of their presence are able to animate the waiting spirits of innumerable disciples. This, however, needs the personal element beyond all others; and in times past it was not easy for the leaders of thought to pass from place to place, lighting up by their presence the way to further knowledge, and keeping alive the enthusiasm for research which, nowadays, is so usual a consequence of the existence of men of genius in our midst, that we have ceased to regard it as in any way unusual or out of the ordinary course. But such free intercourse between separated groups of workers has been rendered easy of adoption only within the Victorian era, and an easily understood accompaniment of it has been the rapid multiplication of those voluntary associations of students pursuing a common object, which under various distinctive names have arisen, as societies, throughout the British Empire in recent years. Previously to the introduction of railway travelling, and the attendant cheap postal system, none but the largest cities, and those only of importance as centres of resort by all ranks and conditions of men, could boast of a "society," in the sense of being an assemblage of students united in pursuit of similar ends, and those the advancement of learning. Places like London, Paris, and Edinburgh, alone

could serve the purpose of such a gathering ground for the reason that, sooner or later, almost every individual interested in the solution of life's problems, would find himself in the metropolis of his native land; and here, possibly for the first time, he would meet his peers in thought and experience, and would enjoy the delights of feeling that others had like pursuits with himself; and, by discussing his own discoveries and difficulties with them, new light would be thrown on his own researches, and suggestions obtained for further investigations. Thus, in a word, a society in the full acceptance of the term would arise; almost without intent at first, there would come about the congregation of men having tastes, ideas, and aims in common; and they would soon become a centre of attraction for others like themselves, until in time a recognised society would be formed from such beginning destined it may be, to be a beacon light to progress, and an illumination for succeeding generations as may be instanced from the earliest associations of this description, such as the Royal Society of London, the College of Physicians, the Royal Society of Edinburgh, the Geological, Linnean, and numerous other associations which now are found throughout the length and breadth of the land.

How signal an influence was forthwith exercised over the advancement of knowledge by such means as these can easily be seen from the history of any one of the more important even of the provincial societies. We here are familiar with one at least of them, and recognise by perusal of the archives of our own institution that without the stimulus of its encouraging aid no inconsiderable part of the developments of a geologico-industrial character which have taken place in the immediately surrounding neighbourhood of Manchester might have remained till now unaccomplished, awaiting the fostering care they have so far fortunately received. An equally striking illustration of the truth of

this general induction, though on a smaller scale perhaps, is afforded in the deeply interesting volume, issued from the press within the past few days, devoted to an account of the life of one of the grand old men of science, William Pengelly, F.R.S., not the least interesting part of this narrative is that which describes the inception and growth of the Torquay Natural History Society, which may be said to have originated through Pengelly's eager wish to associate with himself those of his neighbours who were interested in the study of the rich local treasures of geological remains which revealed themselves to his searching gaze. How much has since been done through the agency of this Society, which for more than fifty years enjoyed the advantage of its founder's immediate care and supervision, need not now be said. The unique and magnificent collection of fossils obtained from Kent's Cavern, all of them arranged with loving and disinterested carefulness by Pengelly's own hands, which are the principal feature in the museum of the Society at Torquay, are a lasting testimony of what association in this direction can ensure. It may very well have been that the indomitable nature of the man, and his soulful devotion to the labour which fascinated him, would have, at all costs ensured his own recognition as a genius in discovery; but unassisted by the ungrudging sympathy, and practical aid of the Society that his own personality caused to grow up around him as its central figure, he could not, in human probability, have left behind him for his life's work, so vast and so complete a monument of industry as he succeeded in doing; nor would the world have benefited to nearly the same extent by his prolonged and self-denying labours.

To take a larger instance of the value to mankind of association in promoting the advance of knowledge, the British Association, though founded on somewhat different lines to those pursued by local societies, offers, a brilliant and

convincing proof of the utility of this mode of stimulating progress. There is something in the actual gathering together of many minds that infuses into each individual present a special intelligence which silent communing alone in the solitude of the study is unable to impart; and, howsoever comprehending the individual mind may be, it fails to perceive surroundings with anything like the same force of grasp, until these are touched here and there by varying lights and shades and colours that play upon them when differing modes of thought and the characteristic expressions of different thinkers are brought to bear upon them in discussion and mutual interchange of ideas. Even the humblest toiler in the field of science has felt the reality of this times out of number. Disheartened by apparently unconquerable difficulty, despairing of unravelling the mystery that perplexes him, seeking in vain for the solution of a problem which seems again and again within his grasp, only to elude him at the moment of seeming victory, he seeks for companionship with some other who has experienced similar distress of mind; together they tread once more the familiar ground of debate, which now becomes the arena for varied modes of combat arising out of the differing appreciation of the factors by varying minds. Fresh views of the old points present themselves under the altered conditions of enquiry, and lo! the much sought for solution is found ready to be applied, and the trouble is past. Scarce a meeting of a scientific society ever takes place without some incident of this description occurring to mark its progress; it may be concerning only a point of detail, or a trifling matter of explanation, but none the less the principle which regulates it is precisely the same as if it was a primary law of nature that is involved; and the truth equally remains that association and the mental stimulus it affords has provided the lever commanding success. Nor is this the case

only as regards matters of theory in science; the truth holds equally in respect of the practical applications of scientific discoveries to the needs of man; and it is an unquestionable fact that very much of the marvellous developments of modern engineering, mechanical, mining and civil, has been in a great measure resultant from the influence exercised on it by the several societies which have been instituted within the past half century or so to foster its advancement. This department of practical science is, for special reasons, particularly remarkable in this respect, and affords, consequently, an apt illustration of the point in question. With the advent of George Stephenson on the field of mechanical construction, and his successful attempt to convert the hitherto imperfectly useful locomotive engines into an usable and trustworthy machine, there commenced an era of activity in the direction both of invention and of application, which has continued unabated up to the present time; and to which we are indebted for the wondrous array of time and labour-saving machinery which gives to existence to-day so changed a character as compared with that which was familiar to our own immediate grand-parents. The electric telegraph; the railways and tramways, steam and electric; the telephone and all the strangely beautiful adaptations of it; the innumerable forms of machines devised to secure the maximum of production at the minimum cost of time and labour; and a whole host of ingenious refinements of earlier discoveries, whereby the needs of the time are served with a more fitting adjustment of means to ends; all these are but details in the great picture of progress which a survey of the history of our own country and of the world during the past sixty years reveals.

And how much of this grand tale of work accomplished, and of progress assured within the life-span of no inconsiderable proportion of those still alive, may we not justly

attribute to the inspiring influence exerted on the minds and activities of thinkers and workers by association? Indeed, rather may it be said, how little of the magnificent total of work accomplished, and triumphs won by science during the nineteenth century, could have been so successfully and assuredly completed, had not the instinct towards co-operation found such ready means of securing full indulgence as was afforded, first by the gregarious tendency of the human being, and secondly, by the introduction of simple and economical methods of journeying from place to place.

But there is another direction, and a very important one to consider, in which societies such as this exercise a power for good that it is impossible to over-estimate the value of. Among their members are always to be found some at least whose laurels have yet to be won, and who being little more than hesitating wanderers over the threshold of fame, need the encouragement to persevere which only they can render who have achieved the guerdon of success, and are thus the worthy patrons of youth. Such younger members are the rank and file, from whom, as merit marks them out conspicuous for advancement, promotions take place from time to time to the ranks of workers distinguished by the benefits they have been the means of conferring on society in general. To these especially are the benefits of societies inestimably valuable. Through them they are enabled to meet the leaders prominent in their own particular line of pursuit, and by the stimulus of contact in direct personal intercourse with the bearers of names rendered illustrious by their owner's greatness, they derive such incentives to exertion as can be found in no other manner, and the effect of which remains with them in all the years of their intellectual development and vigour. Through the same agency of association also, they are enabled to enjoy the advantages of friendly criticism of their own aims and performances, and

in this way to avoid the pitfalls which constantly beset the path of youth and inexperience, and to obtain that kindly encouragement and advice without which the most painstaking care in the absence of information born of contact with all sorts and conditions of surroundings is unavailing to prevent the commission of error and the pangs of disappointed ambitions. In this connection, to a larger extent than in any other direction, have voluntary associations of students and workers been productive of good results in the past; and the consciousness of the truth of this generalisation must always be a helpful recollection on the part of those who might else be possibly inclined to take a pessimist view of the benefits that flow from the large amount of self-sacrifice displayed by the active officers on whom the organisation and successful conduct of each of the least important scientific Society devolves.

It has been said that the prevailing tendency of public opinion regarding any particular branch of knowledge is influenced by the attitude held towards it by the few who, for the time being, are reverenced as the leaders of thought in that direction; and it is undoubtedly a fact, as it ought to be, that this is the case. But for the enunciation of truth it is eminently desirable that the agencies for its dissemination should be not only numerous, but also equipped in the best attainable fashion for due performance of the labour they are expected to perform. To this end the machinery of Societies offers the most facile means of attaining what is desired, for as centres of training they occupy a position which is only rendered more influential by reason of the non-didactic character of the instruction that is given within them. The members of a Geological Society, for instance, when assembled together to hear from one of their number an account, it may be of entirely new observations, or of some hitherto unnoticed features of a well-known stratum or

locality, are prepared to accept the statements which accord with their own knowledge and experience, straightway; but in regard to other matters less familiar they will properly ask for, and receive direct from the author of them, an explanation of the grounds and reasons offered for their acceptance. When these are weighted with the authority of one who has achieved the right to be considered a master of the subject, then they at once obtain a consideration which could not be expected for the conclusions of a younger and untried member; but in the friendly criticism to which his views would then be subject, the latter would receive inestimable benefits which could never by any chance be obtained in the ordinary intercourse of life. In this connection it is interesting to look back just now on the history of geology, and especially of economic geology, as unfolded in the past sixty or seventy years. It is essentially a history of societies, starting from the publication of Lyell's monumental and epoch marking volumes, the growth of the observing spirit manifested itself as one of the earliest factors tending to the development of the modern science of geology; and in the association of observers, in the first instance, a society would take its origin; and soon the intrinsic value to surrounding workers of such an institution would prove sufficiently powerful as an attraction to draw them one and all within the circle so created; and in this way, as the narrative contained in the eloquent and admirable address given here last year by my predecessor, Mr. Mark Stirrup, so clearly shows, our own Society had its origin, and from that origin advanced slowly but surely to be the powerful instrument for good that it has so long proved itself to be. Were we to confine our examination into the truth of the assertion that human knowledge has been largely advanced by voluntary associations, by reference to societies in our own neighbourhood only, we should find ample

evidence of all that has been so far said in its behalf; but when the area included in our survey is made to embrace all the centres of this form of intellectual activity, the force of the illustration becomes overwhelming in its convincingness. So great, indeed, is it then seen to be, that we may even be pardoned the assumption, that but for this all-pervading spirit of collaboration, so peculiarly characteristic of the age in which we live, it would have been impossible for science to have achieved the conquests which are a triumphant record of the struggles of genius against contending difficulties, and of indomitable perseverance which has successfully grappled with obstacles that must have proved all but insuperable to unaided and solitary research. Co-operation and association are the watchwords of progress; and we who are in the happy enjoyment of blessings inherited by us as the grand result of the labours of those who preceded us as enquirers in the field of knowledge and experience, must, if we are worthy recipients of their gifts, demonstrate our gratitude to them by emulating their example, and imitating their deeds. So shall we hope to deserve that those who follow in our footsteps hereafter, may cherish the memory that we leave behind us, and hold us in the same regard and reverence with which we are proud to honour the names of those who bequeathed to us the imperishable traditions of this Geological Society of Manchester.

Mr. Henry Hall: I rise with very great pleasure to propose a vote of thanks to the President for his admirable address. It struck me, as he read it, that it was of practical utility and very considerable literary beauty. I have not listened to anything, I think, more interesting or entertaining in the same kind of way as this address. What I mean to say is, the President has dealt with his subject in an unusually interesting manner. There can be no question,

I think, about what he tries to set forth, viz., that very great value attaches to scientific research in connection with practical work. Sometimes we find that the scientific side of practical subjects is rather looked down upon. In reference to mining, for instance, there are employers who would consider time spent at geological meetings or mining classes to be time wasted.

Mr. STIRRUP: Surely not.

Mr. HALL: I am glad to think, however, that that kind of employer is gradually disappearing. But it cannot be denied that there are employers who are influenced in that direction. They seem to judge a man (I am thinking now more especially of a colliery manager) sometimes by the amount of clay he carries about with him. If he looks, after coming out of his pit, as if he had been rolling in a ditch, they seem to think he must be an industrious and very practical man. The conclusion that I come to when I see him in that condition is that his roadways are low, and that his water levels are probably blocked up. Now there is no question that the man who wants to get on in the future must be one who knows not only all about his own pit, but makes it his business to know what is going on in other pits, and who will take every opportunity, by being a member of societies like this, and in other directions, of finding out what is going on elsewhere in his own avocation.

Mr. R. WINSTANLEY: I have great pleasure in seconding the vote of thanks to the President for his admirable address; and I am sure the meeting will fully endorse the remarks which have been made by Mr. Hall.

The motion was put to the meeting by Mr. Hall, and carried unanimously.

The President briefly acknowledged the compliment.

This concluded the business of the meeting.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XIV. VOL. XXV. SESSION 1897-98.

The ORDINARY MEETING of the Members was held on Tuesday, December 14th, 1897, at the Society's Rooms, Queen's Chambers, 5, John Dalton Street, Manchester.

The President, Mr. JOHN RIDYARD, F.G.S., in the Chair.

NEW MEMBERS.

The undermentioned gentlemen were balloted for and unanimously elected Ordinary Members of the Society:—

Mr. FRANK HEATHER, 35, Dickinson Street, Manchester.

Mr. WILLIAM HALL, B.Sc. (Vict.), Science Teacher, 44, Harrowsmith Terrace, Bolton.

Mr. P. W. D. PICKUP, Rishton Colliery, Rishton, near Blackburn.

Mr. W. A. RITSON, Crumpsall, Manchester.

Mr. JOHN WOOD, M.E., Barley Brook Foundry, Wigan.

ON THE CORRELATION OF THE DOVER AND SOMERSETSHIRE COALFIELDS.

By Mr. G. C. Greenwell, F.G.S., M.Inst.C.E.

Several years prior to the Coal Commission enquiry of 1866-1871, as to the quantity of coal of a workable character remaining in the British Islands, the opinion was expressed by many, including Mr. Prestwich and Mr. Godwin-Austen, that the long range of coalfield extending from Sarrebruck to (or at least in the direction of) Calais pointed towards its continuation to Dover, to say nothing of its further extension to Somersetshire and South Wales, and even to the south of Ireland. The opinion was not generally concurred with: others, including Sir Roderick Murchison, thought differently, and evidence *pro* and *con* was given by these authorities. The lines of argument varied—the idea of the first theorists appears to a very large extent (if not entirely) to be that because the Coal Measures in France were found to be approachably near the base of the Chalk, they would be found approximately near to it on the other side of the Straits of Dover, which was no scientific argument at all; the idea of the other scientists was based upon the great thickness of the upper formations found in England, which had been shown to be superimposed upon the Coal Measures. The former idea was by the subsequent successful experiment at Dover proved in a sense to be right, but it was really no practical reasoned-out geological question at all; the argument, such as it was, was from East to West, but there was no well founded one from West to East.

It should not be forgotten that the advocates of the existence of coal in the south-east of England did not select for their boring in the search for coal any site near Dover, but one at Battle, in Sussex, many miles distant from it, and commencing below the Chalk, where hundreds of feet of strata, in excess of those passed through at Dover between the Chalk and the Coal Measures, were passed through without reaching any Coal Measures. This bore hole was probably on the south side of an anticlinal—(*Query:* Continuation of Mendip)—where, in Somersetshire, proofs have been given that the Mesozoic formations are largely developed, and it is certainly doubtful whether, if this hole had been continued, it would have proved the existence of Coal Measures at all. In this case Mr. Godwin-Austen and his followers would, in the absence of other explorations, have been pronounced wrong, and Sir Roderick Murchison, and his, right. When, in a paper read to the Manchester Geological Society in 1864,* after drawing attention to the great diminution in the thickness of the formations overlying the Carboniferous on the North side of the anticlinal (Mendip) I foreshadowed the near approach of the Coal Measures to the Chalk. I proximately arrived at conclusions which have now been verified.

Having regard to the above, I think it may be justly concluded that the discovery of coal at Dover is due :—

1. To the discoveries in Belgium and France, extended from exposed coal areas to those covered by upper formations, as in the North of England and elsewhere.

2. To certain circumstances which occurred at Dover.

3. To the consequent proposals to bore at the Tunnel Works by Mr. Brady.

* The minutes on which this paper was founded, were made by me in Belgium, June, 1862.

4. To their adoption by the Tunnel Company.

The Dover boring has now been carried down 727 yards 0 feet 6 inches below high water mark, which is a capital datum.

It is not necessary for me to recapitulate the details which have already appeared in the section published by Mr. Brady, it is sufficient to say that after having passed through 385 yards 2 feet of upper formations, not probably very clearly defined, the Coal Measures were reached at this depth.

A few thin beds of Limestone were passed through, above the Coal Measures, probably Permian; they might, however, be limestones of the Upper Coal Measures, and in this case they would most likely be found to contain Spirorbis carbonarius, but there is no record of this. On May 27th, 1867, I read a paper on Prestwichia to the Manchester Geological Society; the specimen shown was a Prestwichia rotundata. The paper was written by Mr. Etheridge on the specimen which I sent to him; to this fossil was attached Spirorbis carbonarius, as pointed out by him.

The Preswichia was from the Radstock (the Upper Coal Measures) series of Somersetshire.

Spirorbis carbonarius is not, however, confined to the Upper Coal Measures, but is very characteristic of the limestone found there, the spirorbis limestone bed being usually of fine texture, and of a light smoky grey colour; although the fossil is minute, it is very recognizable. During the progress of the sinking at Sandwell Park, near Birmingham, the late Mr. Henry Johnson (then managing partner) wrote to me to say that they had received a blow to their prospects by having reached a bed of limestone, and in reply to my enquiry as to spirorbis, wrote that they had,

since the receipt of my letter to him, examined the limestone but could not find any. I then requested him to send me a piece of the stone, and discovered the fossil. On my marking and returning the fragment, Mr. Johnson replied that they had now found many more, and soon afterwards the first seam of coal was proved.

This little fossil is often fragmentary, and difficult to find without a magnifying glass. I have found it at Ardwick, at Leebotwood, and at Nuneaton.

The spirorbis limestone yields a good hydraulic lime. As, however, the non-discovery of this interesting little relic is no proof of its absence, further search may be made. As the resemblance between the "Brown rubbly sand full of brown polished 'millet-seed' grains," 12 feet in thickness, and the iron ore now worked at Westbury, in Wiltshire, and used in the Westbury Iron Furnaces, is undoubtedly great, as observed by Professor Boyd Dawkins, and concurred with by me, some further examination, with analysis, would be desirable, and this can be made when the bed is passed through in the sinking of the pits. As to the correlation between the Coal Measures proved by the Dover boring with those of Somersetshire, much remains to be enquired into.

I have prepared upon the same scale two vertical sections: the first (Plate 1) being that of the boring at Dover (from Mr. Brady's Section), and the second (Plate 2) that of the Somersetshire Coal Measures, so far as explored.

In the first it will be observed that there is in the Coal Measures no appearance of any considerable mass of red and purple shales, nor, as yet, of any representative of that enormous mass of pennant rock, both of which are so prominent in Somersetshire.

These two questions I shall treat separately.

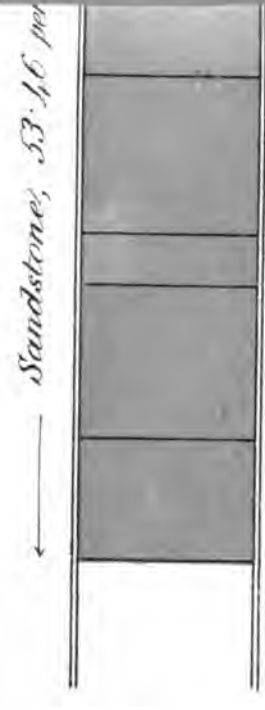
1. Red and Purple Shales.

These in Somersetshire are, as will be seen in the sectio (Plate 2), about 54 yards in thickness, although they var to some extent, but not very much even in other localite where passed through (except perhaps in North Staffordshir and Monmouth); they are always in Somerset found lyin between the uppermost, or Radstock Coal Series, and th second, or Farrington Series.

These strata consist of red and purple shales and re sandstones. I am not aware of their containing any organi remains, although they exist in a form, as these measure contain a little coal in thin seams.

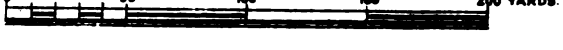
The red beds are not confined to Somersetshire, as the following instances will show, and I doubt if these beds have received the attention to which they are entitled, and it is perhaps premature to express any decided opinion as to their position in other districts correlatively with that of Somersetshire.

I have prepared the section (Plate 3) which, so far as it goes, inclines me very strongly to believe that they may be considered as forming, not perhaps an independent series, but a semi-independent one, separating the Upper Coal Measures from those lying beneath. I think that this idea is very strongly confirmed in North Staffordshire, where an important mass of red sandstones and shales intervenes between the Upper and Middle Coal Measures. I may mention that these Red Measures in North Staffordshire have been depicted in the Ordnance Geological maps as Triassic, and the same in Yorkshire.



Coal strata with 70·24 per c. of Sandstone COAL No. 8 _ 2 ft. 3"	38	0	0			
Coal strata with 87·04 per c. of Sandstone COAL No. 9 _ 2 ft. 9"	64	1	9			
Coal strata with 71·67 per c. of Sandstone COAL No. 10 _ 1 ft. 8"	22	1	0			
Coal strata with 61·35 per c. of Sandstone COAL No. 11 _ 1 ft. 0"	69	0	0			
Coal strata with 41·33 per c. of Sandstone COAL No. 12 _ 4 ft. 0"	46	1	6	354	2	6

SCALE



Localities.	Coal Measures above Red Measures.	Depth from Surface to top of Red Measures.	Thickness of Red Measures.	Coal Measures proved below Red Measures.
1. Radstock, Somerset.....	Overlap	354 yards.	60 yards.	183 yards.
2. Braysdown, ,, ...	226 yards.	335 ,,	54 ,,	199 ,, to No. 5 Vein.
3. Abercarn, Monmouth.....	6 ,,	15 ,,	7 ,,	269 ,, to Black Vein.
4. Chatterley, North Stafford....	3 ,,	4 ,,	161 ,,	79 ,, to Red Mine Ironstone.
5. Keele, North Stafford.....	45 ,,	45 ,,	121 ,,	78 ,,
6. Shire Oaks, Yorkshire (Rotherham Red Rock).....	32 ,,	86 ,,	66½ ,,	357 ,, to Barnsley Seam.
7. Ashton Moss, Lancashire	316 ,,	365 ,,	65 ,,	580 ,,
8. Bradford, Lancashire (near Manchester)	371 ,,	387 ,,	24 ,,	296 ,,
9. Patricroft, Lancashire	0 ,,	4 ,,	58 ,,	363 ,, Worsley 4ft.

From the great extent and position of these "Red Measures," I propose to consider them as the zone of demarcation between the Upper and the Middle Coal Measures of Great Britain: where these measures do not exist, there will no doubt be found some other basis for its definition.

The three series of Coal Measures may be classified as follows:—

1. *Upper Coal Measures:* those lying above the Red Measures.

2. *Middle Coal Measures:* those lying below the Red Measures (inclusive of the Pennant Measures, largely developed in Somersetshire; less so in South Wales, and occasionally developed elsewhere) to and inclusive of the Perrink Coal of the Vobster series in Somersetshire, the Nine Feet Coal of South Wales, the Bullhurst Seam of North Staffordshire, the Silkstone Seam of Yorkshire, the Arley Seam of Lancashire and Cheshire, and the Hutton Seam of Durham.

3. *Lower Coal Measures:* those lying between the last named horizon and the Millstone Grit.

2. Pennant.

This rock, as will be seen by reference to the section (Plate 2), attains in Somersetshire the extraordinary thickness of 900 yards: it consists mainly of compact hard bluish-grey sandstone or gritstone, in beds of uniform colour, and is excellently adapted for building purposes, for which it is in high estimation, and very extensively used.

It contains a few thin seams of coal and beds of shale but the coal seams, so far as proved, do not appear to be of

		Golden Candle Stick	2·0	28	0	0				
		North Shoots		12	0	0				
		Cat		13	0	0				
		Fern Rag	3·6	10	0	0				

temptingly commercial value, and the exploitation of "the Pennant" has been confined to the quarry.

In South Wales the Pennant also attains a great thickness, probably 600 or 700 yards, where most largely developed.

As regards other English coalfields, I do not find any prominent representative of this series. For the latter reason, I am not inclined to press too strongly on its (so far) absence at Dover, but we must not neglect this absence in attempting to correlate the coalfield of Dover with that of Somerset.

The thickness of the Pennant in Somersetshire has been obtained from a careful levelling under my direction, in 1861-62, across the country between Radstock and Marshall's Hill Limestone Quarry, on Mendip: this has been confirmed by Mr. McMurtrie.

Localities.	Depth to Top of Pennant.	Thickness of Pennant.	Depth below Pennant.
Harris's Navigation, South Wales.....	13 yards	With Coal 8′ 11″ in three Seams in 269 yards.	To Lower 4ft., 478 yards.
New Rock, Somerset.....	Denudation ..	Sunk in 178 yards.	To Warkey Course, 456 yards.

From the section of the Dover boring, and from the thickness of Coal Measures thereby proved, I am led to the conclusion that the seams bored through cannot claim any alliance with the Upper Coal Measures worked at Radstock, known as the Radstock Coal Series of Somersetshire, nor, to much if any extent, with the Farrington Series which lies above the Pennant. These proofs do not, however, ignore the possibility that they may have their locale in the New Rock Series (Plate 2), but I am inclined to think that they should

be referred to the very important part of the Middle Se commencing possibly with the Garden course of the M Rock Series of Somersetshire.

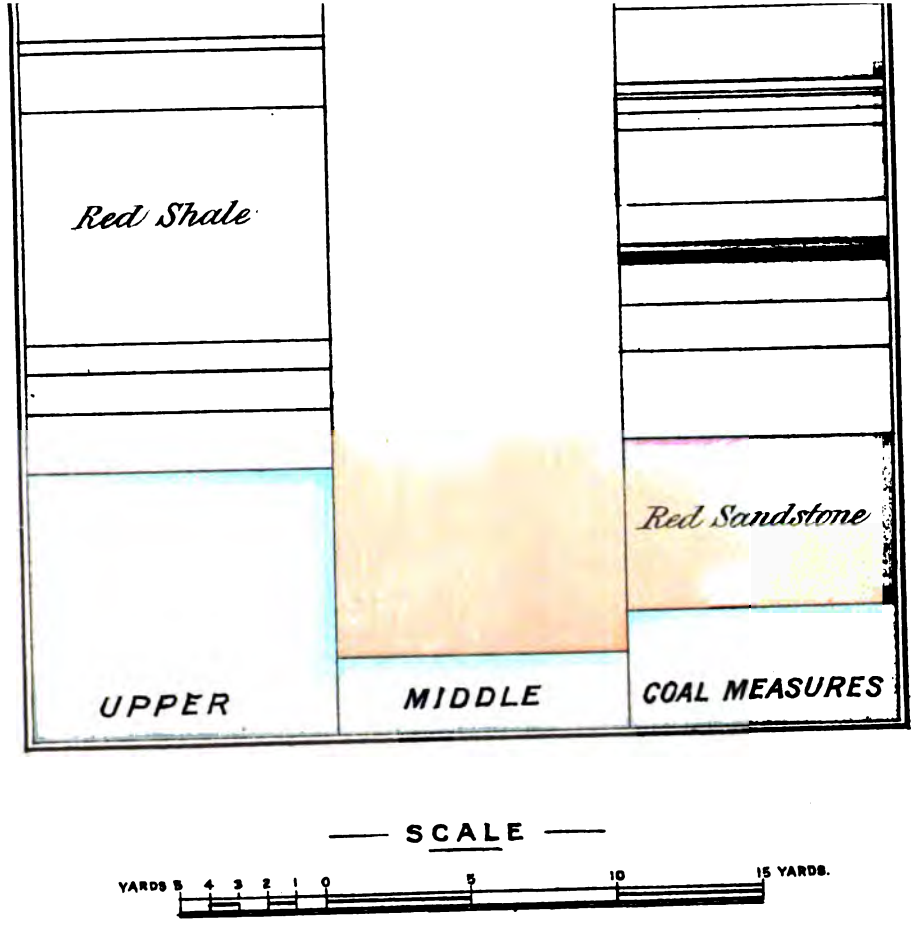
The Palæontological evidence given in the publis statements and reports of the Dover exploration does disprove this, and the evidence from analysis there addu I think strongly confirms it.

3. Palæontological Evidence.

On this point I make my remarks with great humility. In referring to the opinion of M. Zeiller (Engineer Chief of Mines, Lecturer on Vegetable Palæontology to t School of Mines, Paris: Transactions of the Academy Sciences, Paris), that the presence of Neuropteris Scheuc zeri indicates the position of the Dover Series as bein identical with the Farrington Series of Somersetshire, I be to refer to the excellent work of Mr. Robert Etheridg F.R.S., &c., entitled "Fossils of the British Islands."

The plants referred to by M. Zeiller, and found in th strata bored through at Dover, were observed in the cor obtained at the depths of 631, 633, and 676 yards below th sea level, or 245½, 247½, and 290½ yards below the top of th Coal Measures where pierced, their bedding being in "har grey sandstone," "dark grey sandstone," and in "stron dark grey bind," respectively; they are all confined to th very moderate range of 45 yards (chiefly siliceous strata) ou of 341 yards of Coal Measures; and shales are the mo usual repositories of coal plants. The names of the plan referred to by M. Zeiller are:—

At 631 yards: "Neuropteris sphenopteroides," "neuro teris Scheuchzeri," "neuropteris tenuifolia," "lepidodrend aculeatum," and "carpolithes corculum."


Red Shale
Red Sandstone
UPPER
MIDDLE
COAL MEASURES
SCALE
YARDS 5 4 3 2 1 0 5 10 15 YARDS.

At 633 yards: "Neuropteris Scheuchzeri," "neuropteris rarinervis," "neuropteris tenuifolia," "cyclopteris," "calamophyllites Gœpperti," "lepidostrobus variabilis," and "cordaicarpus."

At 676 yards: "Neuropteris Scheuchzeri," "lepidodendron lycopodioides," and "stigmaria ficoides."

M. Zeiller observes: "All these species indicate Coal "Measures, but the greater part do not admit of a more "precise statement. Indeed, the calamophyllites, lepido-"dendron, lepidostrobus, stigmaria, that I have just cited "are found indifferently in nearly the whole thickness of "the Middle Coal Measures, and, in part at least, in the "upper stratum. The neuropteris tenuifolia shows itself, "above all, common in the Valenciennes basin, in the most "elevated zone of the Charbons gras, and flenus of the Pas "de Calais; yet it is observed, though rarely, at the base of "the middle zone of the same basin: it will not serve there-"fore as a basis of level."

"It is not the same, fortunately, with the neuropteris "rarinervis, and the neuropteris Scheuchzeri. These indeed "have only been observed in America, as well as in Europe, "towards the top of the Middle Coal Measures, or at the "extreme base of the Upper Measures. In France they "abound in the upper zone of the Valenciennes basin, and "they have not been met with below, except quite at the "summit of the middle zone, and then at one or two points "only."

* * * * *

"It may therefore be concluded from the presence of these "two species in the Dover boring, . . . that they cannot "be either more recent than the beds of Radstock in

"Somerset, or more ancient than the deepest beds of the "upper zone (Charbons gras et flenus) of the Pas de Calais."

On referring, however, to Mr. Etheridge's Fossils of the British Islands, under the head of Plantæ (carboniferous), I find of mariopteris only two varieties, viz., mariopteris muricata and mariopteris nervosa, as having yet been discovered in Britain, the former in the Lower, and the latter in the Upper, Middle, and Lower Coal Measures.

Neuropteris Scheuchzeri: found (?) in the Upper; (?) in the Middle; and in the Lower Coal Measures.

Neuropteris tenuifolia, in the Upper and Lower Coal Measures, and in the millstone grit. Lepidodendron aculeatum (*vide* sagenaria aculeata), in the Middle and Lower Coal Measures, and lower limestone shales.

Carpolithes corculum, not yet discovered in Britain—except at Dover. Neuropteris rarinervis, not yet discovered in Britain—except at Dover.

Cyclopteris: cyclopteris dilatata in Upper, cyclopteris flabellata, in Upper, Middle, and Lower Coal Measures, and in lower limestone shales; cyclopteris obliqua in Middle and Lower Coal Measures, and in lower limestone shales; cyclopteris orbicularis, in Upper and Middle Coal Measures; cyclopteris reniformis in Lower Coal Measures, and in lower limestone shales; cyclopteris semi-flabelliformis, in Middle and Lower Coal Measures; and cyclopteris tricomanoides, in Lower Coal Measures, and in lower limestone shales. Calamophyllites Gœpperti: Not discovered in England, except at Dover.

Lepidostrobus variabilis, in (?) the Upper, in the Middle, and Lower Coal Measures, and in lower limestone shales.

Cordaicarpus: Carpolithes corculum: Not discovered in England, except at Dover. Carpolithes alatus, and carpo-

lithes marginatus, in Lower Coal Measures; carpolithes helicteroides, and carpolithes zamoides, in Middle and Lower Coal Measures; and carpolithes sulcatus in Lower Coal Measures, and lower limestone shales.

Lepidodendron lycopodioides, *vide* lepidodendron elegans, in Upper, Middle, and Lower Coal Measures; in the millstone grit; in the carboniferous limestone; and in the lower limestone shales.

Stigmaria ficoides: in the Upper, Middle, and Lower Coal Measures, in the millstone grit, and in the lower limestone shales.

We must not conclude that because a certain fossil has not hitherto been discovered in a certain zone it does not exist there, and if the statements extracted from M. Zeiller's report and the parallel statements taken from Mr. Etheridge's book are compared together, it is equally probable that the coal formation of Dover is referable to the Middle and Lower Coal Measures; their want of relation to the Upper Coal Measures is apparent from the absence of the red measures from the Dover field so far as proved.

4. Analytical Evidence.

I now proceed to the examination of the subject from the analytical point of view. There is a very marked difference between the constituent parts of the different varieties of the substance called coal. Passing over this, which is sufficiently well known, I will now compare the analysis of the coal proved in the Dover boring, which has been given to us by Mr. Brady, with those of other coals of Great Britain. These I tabulate as follows:—

	Carbon.	Hydrogen.	Nitrogen.	Oxygen.	Sulphur.	Ash.	Per cent. of Coke.
KENT, Dover—2ft. 9in. Seam..	83·80	4·65	0·97	3·23	not given.	not given.	not given.
SOMERSETSHIRE—Farrington..	Hydrocarbons.... 31·40				1·27	10·19	54·14
SOUTH WALES, Machen :— Rock Vein, Upper Middle	71·08	4·88	0·95	17·87	1·37	3·85	65·02
Do. Upper Middle ..	77·98	4·39	0·57	8·55	0·96	7·55	62·50
Do. Bedwas (?) Upper Middle..	80·61	6·01	1·44	1·50	3·50	6·94	71·7
MONMOUTH AND GLAMORGAN, Ebbw Vale Lower Middle	89·78	5·15	2·16	0·39	1·02	1·50	77·5
Rock Vein, Vivian's Merthyr Lower Middle (?)..	82·75	5·31	1·04	4·64	0·95	5·31	67·1
Rock Vein, Graigola Lower Middle	84·25	4·15	0·73	5·58	0·86	4·43	85·1
Average Upper Middle	76·56	5·09	0·99	9·31	1·94	6·11	66·41
Average Lower Middle	85·57	4·84	1·31	3·54	0·94	3·75	76·6
DURHAM, Hedley's— Lower (?)	80·26	5·28	1·16	2·40	1·78	9·12	72·31
DURHAM, Busty Bank— Lower	83·67	4·27	0·63	6·89	0·78	3·08	74·3
Do. do.	Hydrocarbons..... 25·7						74·3

The whole of the above analyses, with the exception of those of the Dover Coal, Farrington, and the (No. 2) Lower Series Coal of Durham, are taken from the Reports on Coals suited to the Steam Navy (1848-51).

In comparing the analysis of the Dover coal with that of the average of the analyses of the 37 Welsh coals referred to in Mr. Brady's report, the coincidence is remarkable, but it is to be observed that this average must be taken with a qualification.

The Welsh average is taken from a wide range, it includes :—

	Carbon.	Hydrogen.	Nitrogen.	Oxygen.	Sulphur.	Ash.	Per cent. of Coke.
Anthracite— Jones and Co.	91·44	3·46	0·21	2·58	0·79	1·52	92·9
Machen— Rock Vein	71·08	4·88	0·95	17·87	1·37	3·85	65·2

It is to be especially observed that the last adduced analysis is that of a coal which belongs to the Farrington or, probably, the New Rock series of Somersetshire (Upper Middle Coal Measures), and that with the exception of a very few of the samples the whole of the 37 Welsh analyses are of coals corresponding with the Vobster series, or Lower Middle Coal Measures.

Having carefully considered the whole of this part of the subject, I venture to give the opinion that the coal section proved by the boring at Dover is referable to the Lower Middle Series of the Coal Measures of this country, and that this view is confirmed by both the stratigraphical and palæontological evidence hereinbefore given.

I am aware that Mr. Mc.Murtrie (of Radstock), whose study of the Somersetshire Coalfield for a great number of years, entitles his opinion to great respect, leans to the idea that the Dover coal borings are referable to the Farrington series of Somersetshire; and that such is also the idea of some other geologists, their opinions being more or less, but principally, based upon palæontological grounds; but I am, notwithstanding, disposed to consider that the above combined arguments adduced in favour of their lower position in the Coal Measures are not to be easily overcome.

Professor Boyd Dawkins said: I have very great pleasure in proposing a vote of thanks to Mr. Greenwell, who I am sure we are only too glad to see amongst us again.

Mr. Stirrup: I have also very great pleasure in welcoming Mr. Greenwell on this occasion. He does not often visit us. We know that he has taken a special interest in the Somersetshire Coalfield, and when he states his opinion upon the exact stratigraphic position of that coalfield, as compared with the beds at Dover, it is impossible to pass it by unheeded, although it may differ from the opinions of some other geologists. I second the vote of thanks proposed by Professor Dawkins.

The motion was put to the meeting, and carried unanimously.

Mr. Greenwell having acknowledged the vote of thanks,

Professor Dawkins said: I think, if I might make the suggestion, it would be very convenient to have the paper printed and distributed amongst the members before discussion is entered upon. The subject is one which has been very much discussed during the last seven or eight years, and I feel that I could hardly do justice to Mr. Greenwell's paper—although I may say I have had a good deal to do with these explorations myself—unless I had exactly what he has said before me. In this case we might very well follow the example set by the Institute of Mining Engineers and the Institute of Civil Engineers in London. I am sure it would be a great advantage.

The President: The members will probably all agree that it would be convenient to defer the discussion to another meeting.

The discussion was accordingly postponed.

In the absence of the Author, the following communication was read by Mr. BARNES:—

NOTES ON HEMATITE FOUND IN THE MAYPOLE SINKING PITS.

By Mr. GEORGE CALDWELL.

In continuation of my notes which were read before the Society in April last, I now have pleasure in exhibiting two specimens of iron ore obtained from the Coal Measure strata immediately below the Permian Sandstone in our Maypole Sinking Pits. The Sandstone was pierced at a depth of 150 yards from the surface, and was followed by eight yards of hard white rock and three to four yards of hard grey rock, the latter containing bands of hematite conglomerate, from three inches to six inches thick, the specimen of which is labelled "A 160 yards." The following is an analysis, viz.:—

	Per cent.
Iron	28·8
Insoluble	50·2
Phosphoric Acid	0·22
Carbonate of Lime	3·57

We next met with blue shale, slightly coloured and streaked red from the soft portions of hematite above, and at 25 yards below the Red Sandstone, or 175 yards from the surface, we found another series of bands of hematite, of a different kind, similar to Kidney hematite, the specimen of which is labelled "B 175 yards." This has not been analysed. Recently we have passed through a seam of coal but have not yet been able to correlate it. The specimens will probably prove interesting to some of the members of the Society.

The PRESIDENT said: You will be aware, gentlemen, that the sinking referred to, which is being made by the Moss Hall Colliery Company, is an important undertaking. Owing to the presence of large volumes of water in the shafts, they have met with immense difficulties in passing through the upper strata, before the Coal Measures could be reached. The sample before us is the first of hematite, I understand, which has been discovered by them. Now, as Mr. Caldwell reports, one of the seams of coal has actually been passed through, and good progress is being made with the work. The thanks of the Society are due to Mr. Caldwell for sending us the specimens and the communication which we have heard read.

Mr. STIRRUP moved a vote of thanks to Mr. Caldwell, who, he said, had been good enough on previous occasions to send interesting samples of the strata passed through. He hoped they might have ultimately a complete section of the sinking presented to the Society. All these sections through the Permian were extremely valuable to all engaged in coal mining in Lancashire.

The vote of thanks was seconded and passed unanimously.

FOSSILS FROM THE CARBONIFEROUS LIMESTONE.

Exhibited by Messrs. HOLROYD and BARNES.

The PRESIDENT called attention to a fine collection, consisting of about two thousand carboniferous fossils from the cabinets of Messrs. Holroyd and Barnes, which were on the tables. Some of these have been figured in recent memoirs of the Palœontographical Society (1896-7). Those, said the

President, who had now an opportunity of seeing the specimens would acknowledge that they were an exceedingly fine series, and the Society's best thanks were due to Messrs. Holroyd and Barnes. He moved that a vote of thanks be given them.

The motion was seconded by Mr. CLEGG LIVESEY, and passed unanimously.

Professor BOYD DAWKINS, who supported the proposition with great cordiality, said: This is certainly one of the best collections of carboniferous fossils I have seen in this part of the country. They are very beautiful, and most of them have been got out in the most wonderful state of perfection. It is very rarely that we see fossils so well preserved and so completely free from matrix.

Mr. STIRRUP: I should like to ask the gentlemen who are exhibiting these specimens where they are from—if the whole of them are from Derbyshire, or more distant parts of the country.

Mr. HOLROYD: Respecting the localities of these fossils I may say that they are a representative collection of Mountain Limestone fossils from various parts of Derbyshire, including Park Hill, near Longnor, on the borders of Staffordshire; and there are also some from the Isle of Man. Generally speaking, the fossils are from the uppermost beds of the Mountain Limestone, having been deposited in the shallow waters of the carboniferous sea. The names and exact localities are given on the labels.

Mr. STIRRUP: Have you extended your researches to Ireland?

Mr. HOLROYD: No, I think there are no Irish specimens.

Mr. BARNES: A few fish teeth.

Mr. Holroyd: Mr. Barnes reminds me that there are a few fossil teeth of fishes from Ireland. These are from Armagh. An interesting feature, as you look over the collection, will be the large predominance of the lamellibranchiata—fossils hitherto very greatly disregarded as coming from the Mountain Limestone rocks. You will find the series very well represented in the trays on the table. You will also notice that steps have been taken to polish a number of the fossils on the outside, so as to show the septal divisions in the case of the cephalopoda; and in some, interesting sections have also been made through the centre of members of the Nautilus family in order to show the siphuncle.

This concluded the business of the meeting.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XV. VOL. XXV. SESSION 1897-98.

WIGAN MEETING.

The ORDINARY MEETING of the Members was held on Friday, January 14th, 1898, in the Mining School, Wigan.

The President, Mr. JOHN RIDYARD, F.G.S., in the Chair.

NEW MEMBERS.

The following gentlemen were balloted for and unanimously elected Ordinary Members of the Society:—

Mr. PETER BODEN, Manager, Butterworth Hall Colliery, Milnrow, near Rochdale.

Mr. JAMES W. GLOVER, Mining Engineer, 41A, Victoria Buildings, Manchester.

Mr. ISAAC JAMES, Manager, Wigan Junction Colliery, Abram, Wigan.

Mr. JOHN LIVESEY, Colliery Manager, 117, Stoneclough Road, Stoneclough, Manchester.

Mr. HENRY LOWE, Manager, Limehurst Colliery, Limehurst, Ashton-under-Lyne.

In the absence of the author, the following paper was read by Mr. WILLIAM SAINT, one of the Hon. Secretaries :—

FURTHER NOTES ON IRRUPTIONS OF COAL INTO THE "THICK COAL" WORKINGS AT HAMSTEAD COLLIERY.

By Mr. FREDERICK G. MEACHEM.

(Communicated by Mr. John Finch.)

In view of the discussion of my paper* taking place at the Wigan Meeting of the Society, I have much pleasure in laying before the members the following supplementary notes :—

We have driven new roads some 800 yards from the point previously described in my paper. These roads are for the purpose of developing an area of coal which we have lately acquired. The present workings are situate between four hundred and five hundred yards from any place where the coal has been extracted, so that whatever may be the cause of these new bumps and outbursts, I think we may assume that previous workings do not affect them. The depth from the surface to the top of the coal at this point is over 700 yards, and the section of coal is as follows :—

	Ft.	In.
Coal	11	0
Soft Dirt or Fireclay	4	6
Soft Coal	4	6

We have driven the new roads a distance of some two hundred yards without much inconvenience, but the last seventy or eighty yards has given us great trouble and anxiety. The bumps or outbursts, of which we have had

---

* Trans. Man. Geol. Soc., Part III., Vol. XXV.

several, took place in the form as before, namely, bursting of top or bottom, but they have now assumed an altogether different form, and are very much like those at Broad Oak Colliery, described in a paper* by Mr. Dickinson, inasmuch as the coal is burst out from the front of the driving. On April 14th, 1897, just as the men had left work an irruption took place as shown on the accompanying diagram, *Plate 1.* The coal was burst out of the solid for a distance of fifteen feet, the tub, which is of iron, was at the position marked A., and was blown back a distance of fifteen yards in the road, and a big hole knocked through the plate by a piece of coal. One of the men who was about forty yards from the back states that he was proceeding outwards when he heard a tremendous noise, and he was blown over for a distance of several yards before he recovered himself. He was only slightly injured by the small pieces of coal which he describes as shooting around him as though from a Gatling Gun.

As regards the cause of these bumps, I am of opinion that weight alone is the moving factor, and when resistance is overcome, the burst takes place instantly. As a precaution against these outbursts we have tried wide driving as suggested by Mr. Miller. This we can only do in cases where we are near the face. We had been doing this for eight or nine days, when on May 11th, in the night time, whilst the men were absent, an enormous bump occurred and smashed the place in, tons of fine slack was found lying about and the roof was badly broken.

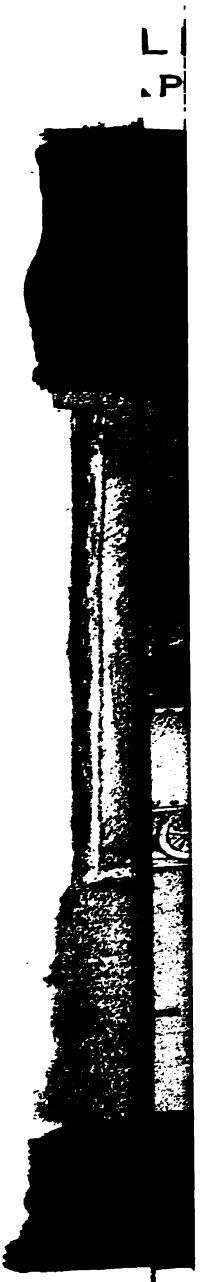
Since then we have tried to open a side of work near a fault, and after having re-timbered the roads three times with larch, eight to nine inches diameter, and having about

* Trans. Man. Geol. Soc., Part VIII., Vol. XXII.

twelve men disabled, we were compelled to abandon it *(see Plate 2)*. This is the first case where we have been completely beaten, and tends to show that the fault is a line of weakness, and that the superincumbent weight is more instant in its action than where the rocks are connected and can bend above the roads and openings.

I am now conducting a series of experiments on the temperature of the strata and also upon the oxidisation of the coal, in company with my friend, Dr. J. Haldane, of Oxford. So far we have found that where we experience the most "bumps," and therefore, most mechanical movement, the natural temperature of the coal is increasing. It would be interesting if some of the members of the Society, who are mining at depths exceeding fifteen hundred feet, would test a few holes bored, say ten feet, into the solid coal, and see whether similar changes are taking place. A maximum and minimum thermometer should be used. It should be carefully read and the needles set before being placed in the bore-hole, and left plugged up not less than twelve hours, after which it may be withdrawn, and the readings carefully noted. I shall be glad to hear from any member upon the subject.

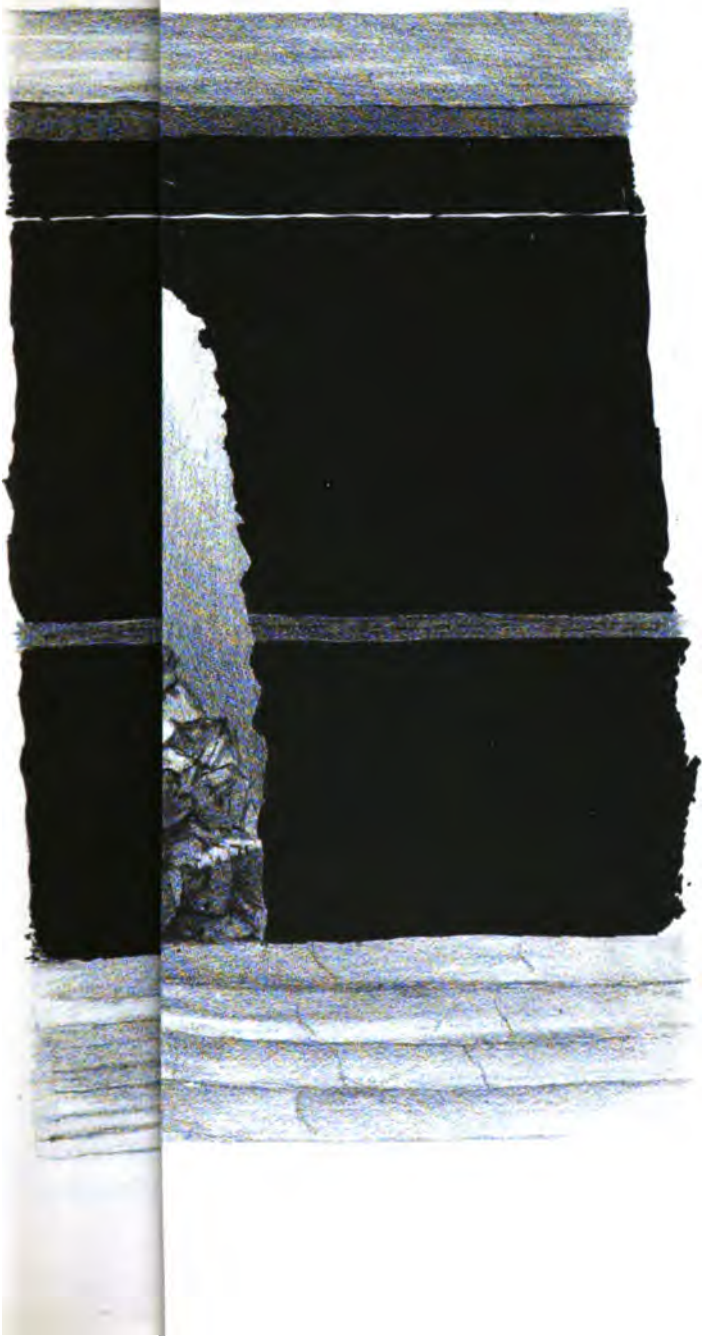
The President said that the Society was indebted to Mr. Meachem for his interesting communication, and also for his previous paper on similar outbursts of coal at Hamstead Colliery, which were admirably shown on eight cartoon drawings. He had described something which, fortunately, was not usually met with in coal mining. He would be glad to hear what the members might say on the subject with the view of ascertaining whether it was possible to prevent these sudden irruptions, or to limit their extent. In his experience of mining in Lancashire, he had never met with any outburst like those described by Mr. Meachem;



P

N.

Trans. Man. Geo. Soc. Part XV. Vol. XXV.
To illustrate Mr. Fred. G. Meachem's paper.



but it had been brought to his knowledge that in the Seven Feet Mine, which was extensively worked in the neighbourhood of Manchester, in driving strait work, the floor of a place that had been left over-night probably four or five feet high had been lifted and broken, so that the timber was destroyed, and the height of the road was materially reduced. That mine was underlaid by a stratum of fireclay, which would be affected by the superincumbent weight acting on and causing a subsidence of the pillars, and a simultaneous upheaval of the floor. That, he thought, was the generally accepted explanation. They would all recognise the importance of the matter referred to in the papers, which were now open to discussion.

Mr. Saint said that they could all appreciate Mr. Meachem's anxiety to solve the great difficulties with which he had to contend owing to the irruptions met with in working the Thick Coal at Hamstead Colliery, and also his kindness in bringing the subject before the Society, so that they might have the benefit of his experience of these rare occurrences. It might assist them if he recalled to their recollection the circumstances attending similar outbursts of soft coal in the Royley Mine, at Broad Oak Colliery, near Ashton-under-Lyne, the particulars of which were brought before the Society in a paper read by Mr. Joseph Dickinson. The coal seam dips at the rate of 1 in 2½; the workings were being extended to the deep, and until recently the mode of working was on the pillar and stall system. The seam gave off firedamp freely. The outbursts began when the drivings had reached a depth of about 500 yards from the surface, and they occurred at frequent intervals; some of them were very large and took place without previous warning. In one case no less than three lives were lost, the men being buried before they had time to move their positions. But within the last two or three years a modified form of long-

wall working had been adopted; with bore-holes carried well in advance in the leading levels, and although the workings continued to increase in depth, there was a marked decrease in the number of outbursts, and when they did occur, they were of considerably less violence and extent. Their plan of working was to drive, from the engine brow, levels about 120 yards apart, and to work the coal out towards the rise. The "soft coal" or "minings" was stowed in the goaf; the roof settled gradually behind the working faces, consolidating the packs and diminishing their tendency to heat. If a pack showed signs of heating it was easily approachable from the gate roads, and they were able to deal with it before it had time to ignite and become dangerous. In this manner, by boring large holes five or six yards in advance of the leading drivings, and opening out an extensive working face, the roof subsided gradually, and the pent-up gases were able to escape, and thus relieve any pressure which might be due to that cause. Under present conditions it would appear that there was less danger arising from irruptions than formerly, and the improvement might safely be attributed to the adoption of a suitable system of working the mine. There appeared to be a divergence of opinion as to the cause of the irruptions. Some held that they were due to the presence of gas or to superincumbent pressure; others to firedamp and pressure combined. It would be interesting to know whether there was any practical difficulty in the case of the Hamstead Thick Mine which would prevent the opening out of a large face of working in one of the layers of coal on the Longwall principle, and thereby relieve the tension of the surrounding strata. The experience at Broad Oak seemed to indicate the direction in which the difficulties at Hamstead Colliery might be reduced or overcome.

Mr. J. Unsworth said that it was a subject on which he

was not prepared to say anything that could be of advantage to the discussion, inasmuch as his experience did not extend to any mines of the character described in the paper. Unfortunately, he had never had a thick coal under any circumstances to deal with, but so far as he could judge it would seem that the irruptions were caused wholly by weight or by weight and gas together. Evidently from what Mr. Meachem said as to the coal in one outburst being sent out as if from a Gatling gun, it pointed to some very powerful force suddenly liberated. If it was, as the President suggested, that the superincumbent coal sinking into the soft under clay caused these irruptions, it could hardly have the force necessary to scatter the coal broadcast. They seemed more likely to be due to pent up force of some kind or another, which was suddenly liberated and produced those disastrous effects. Whatever was the cause they could not be otherwise than indebted to Mr. Meachem for bringing those particulars before them. The subject was of great interest to him, and there must be other members of the Society to whom outbursts of that kind were altogether unknown. He had seen a case of a floor lifting a foot or two in the night, but he had not seen cases like those described by Mr. Meachem, where the workmen had difficulty in getting out of the road, through them coming suddenly upon them. Still the two things were, he thought, bound together in some sort of way, and the same force that would lift the floor and cause the roof to sink so as to bring them almost together in a few hours, was the same which was at work at Hamstead, and with which Mr. Meachem found it so difficult to deal.

Mr. J. S. Burrows said that he had followed the paper on the Broad Oak Colliery and the present paper with great interest. He held that there must be two causes. They saw the floor lifting both in narrow work and where the pillars

were being got. He had seen the roof break down in narrow work, but he had never met a case where the coal had been dislodged from the face as in the present cases. It had always been a difficulty in his mind to account for that. He could not but think that the measures surrounding the coal were in some sort of tension, or compression, and as soon as they touched the place the coal was released and shot out. He could not think it was due to gas, because if it was, surely someone would find a trace of gas at some time, but he did not think that in the cases at Hamstead there was any mention of gas. He was sure it must be a cause of anxiety to those who have to deal with it, and we should be thankful that we have thinner mines in this district.

Mr. Tonge moved a hearty vote of thanks to Mr. Meachem for his paper and for the drawings he had been good enough to prepare for them, and said they must have cost him an immense amount of labour. They were certainly well done, and exhibited the occurrences in the clearest possible light. He was sure they were all indebted to him for bringing such an interesting subject before them. If they had not had much experience of such outbursts, they would no doubt excite much interest in the minds of all of them, and they would seek to obtain further information.

Mr. Mathews seconded the motion, and said he had not had experience of outbursts of that kind, but he had experienced great difficulties in the roadways in some of the deep pits of South Wales, where, having put in brick arching, they had again to resort to timbering, through the strata being unsettled and the floor lifting. After some little time the ground became settled, and after re-arching the roads stood much better than previously.

The motion was then heartily passed.

Mr. J. Tonge, F.G.S., read the following further notes on "The Patent Hydraulic Cartridge."

THE PATENT HYDRAULIC MINING CARTRIDGE.

By Mr. James Tonge, F.G.S.

At a meeting of the Geological Society, held here in May last, when a paper* was read on the new Patent Hydraulic Cartridge for breaking down coal in mines, it was understood that as the cartridge had only been used at the Hulton Collieries, another opportunity should be given to the members to know of its further success, or otherwise, when it had been tried in various mines.

To-day we supply some particulars of further experiments and of further work.

Briefly, we may say that during the eight months that have passed since our last meeting here we have not been pushing the machine upon the market for sale.

We have confined ourselves to work or experiments that about four men could carry on, and we have in this way been making ourselves acquainted with the characters of the various seams of coal in respect to their behaviour under pressure.

When we were last before you, we had the idea that the thickness of the seam would govern and be the measure, to a large extent, of the power and the character of cartridge required.

* Trans. Man. Geol. Soc., Part X., Vol. XXV.

This, we have ascertained, is not strictly so. Bands of dirt running in the coal very materially affect the behaviour of the coal under pressure, and cause us to have either to exert a greater pressure in some cases, or to require a greater movement up or down of the pistons from the cartridge.

Then, again, some seams are very soft and allow the pistons to cut their way separately, and the cartridge to cut its way bodily, into the coal.

Still again, some coals are very elastic, and even after we have made an opening or parting of two or three inches, in a few seams the coal has sprung back to its place immediately we have taken the pressure off. In comparatively few cases have we found the thickness to be the cause of only partial success.

These trials have enabled us to ascertain more clearly and fully what is required, and we have accordingly made them now of three different sizes, one of which has a greater travel of piston.

We now have confidence that by the little alterations in detail which we have made, and by the various sizes, we shall be able to break down the coal in mines of any character or thickness.

We have found it convenient and applicable to pillar and stall work as well as to longwall; to breaking coal down where it is holed underneath, and to lifting it up where the coal is "feyed." We have also found it very well adapted for breaking the roof in roads.

PARTICULARS OF TRIALS AT VARIOUS COLLIERIES, MAY TO DECEMBER, 1897.

Colliery.	Name of Seam.	Result of Trials.		Remarks.
		Successful.	Partially successful.	
1	Trencherbone	..	3	Coal was moved a great deal, but would not fall.
2	Do. ...	2	..	Very good shots.*
3	Crumbrook	5	..	Four of these were longwall shots, and were very good. One shot in straitwork with one end cut took a little longer to get down.
4	Shuttle.....	2	..	Seam 3ft. 6in. coal came down very large.
5	King Coal	5	..	Coal broken from floor, but left all in one lump, in each case.
6	Flockton	4	..	Thin seam, coal-cutter used; brought coal down *easily*.
7	Silkstone	10	..	Very suitable for this coal.
8	Parkgate	2	..	Do. do. do. do.
9	Doe	5	..	Do. do. do. do.
10	Do.	3	..	"Feying."
11	Hunslet	6	..	Three breaking down and three "feying."
	Highley	4	..	All "feying."
12	Three Yard Seam.	1	..	This seam about 4ft. 6in. thick.
	Six Foot Seam ..	1	..	6ft. thick. Seven or eight tons brought down with this shot.
13	Wigan Four Feet	..	3	Three shots "on face." Only fairly successful.
	Do. do.	2	..	Two shots "on end." Very good indeed. Ten tons brought down.
14	Arley	2	..	Strait work.

* The term "shot" is retained for convenience.

Colliery.	Name of Seam.	Results of Trials		Remarks.
		Successful.	Partially successful.	
15	Arley	..	6	Six shots "feying." Not successful owing to drill holes being too large, and crooked.
16	Do.	9	..	Eighteen yards of coal brought down, broken off from back of hole in each case. All round coal.
17	Do.	8	..	"Feying."
18	Do.	2	2	Two shots in wide work. Very good. Two shots in strait work, not successful.
19	Do.	4	..	Four shots in *very soft coal*, "on face."
20	Wigan Five Feet.	..	3	Strait work. Not quite sufficient strength with this cartridge for this thickness.
21	Cannel	3	..	Two breaking down, one lifting up.
22	Do.	..	2	Coal too thick. Strait work.
23	Yard	3	..	Ten yards of face brought down.
24	Do.	2	..	Six yards of face brought down.
25	Do.	..	..	Several shots tried here. All successful.
26	Mary	1	..	Very good trial. Three tons of good round coal.
	Colonel	..	2	Coal too soft for cartridge "on face"; think it would be alright "on end."
27	Three feet	3	1	3 shots "on end," 1 shot "on face."
28	Moss Seam.....	3	..	"Feying." Coal 4 ft. thick. Very good round coal produced.

HULTON COLLIERY.—Arley Mine.

Two Cartridges used constantly in two districts since July 13th, 1897.

No. of shots fired, to December 10th, 1897 2049
Average time of each shot ..... 9 minutes.

Average Results of Six Months Working in a Seam using 2 Hydraulic Cartridges:—

1.—Increased Value of Coal gotten.

Out-put per day 225 tons.

Percentage of round increased from 69 per cent. to 78 per cent. or 20¼ tons (taken after screening and filling in wagons).

Increased Value of 20¼ tons at 5s.—the difference in value between round coal and slack—£5 1s. 3d. per day, for 2 Hydraulic Cartridges.

2.—Increased Economy over Explosives.

2 Cartridges used each 25 times replace 80 explosive shots.

	£	s.	d.	£	s.	d.
Cost of 80 shots at 4d.	1	6	8			
Wages of 1 shot lighter	0	5	3			
				1	11	11
Wages of two men to work the 2 machines ..				0	10	6
Value to the colliery of the 2 machines each day				1	1	5
Deduct for repairs and original outlay				0	6	5
Increased economy per day				0	15	0

Total Gain each day for 2 Hydraulic Cartridges.

Increased value of coal	5	1	3
Increased economy over explosives	0	15	0
	5	16	3

or £2 18s. 1½d. for each Cartridge for each day.

The PRESIDENT said that Mr. Tonge had been very honest in dealing with the subject. He had given them the results whether they were on the rosy or on the thorny side, and thanks were due to Mr. Tonge for bringing the matter before them in the way he had done.

Mr. TONGE then described the mechanism and explained how the apparatus was worked. He also answered several questions as to the working pressure, the use of the cartridges, and the number of men required to work them.

Mr. UNSWORTH said, as reported to him, there was one man at Hulton Colliery whose duty it was to go with the machine. He went into the places and found there all the other tackle before him; the collier had had to provide that in getting the place ready. The hole was drilled, and the collier got all the tackle except the pump, and the man who had to fire the shot went in and coupled the pump and it worked satisfactorily. He then went to another place and took the pump with him, and in the meantime the next collier had fetched all the tackle, and that was why so little extra labour was required. There was no difficulty at all. The collier walked ten or twelve yards and brought the tackle, and the shot firer had everything to his hand. When the machine came to be used in a very thin seam it was very difficult to get across the coal face, and then they found it was not so economical as Mr. Tonge did, at the Hulton Colliery. Their colliers were not used to an instrument of that sort; they kicked very strongly against drilling the hole, but with some little difficulty they got it done. They found, however, at his place it needed two men to go about with the machine, because they could not get the collier to go from place to place to fetch the apparatus. They had to cart the whole of the paraphernalia about from place to place, and it needed two men, and he did not think

in a single instance did they get the shot in so short a time as Mr. Tonge did at Hulton Colliery. He was quite satisfied that the circumstances at Hulton were so favourable to the working of the apparatus that there was no difficulty whatever in doing it. The colliers fell in with it because they found it to their advantage. They got the coal down practically with only the same amount of labour as they had expended before, and upon the whole it was a gain to them and consequently they fell in with it quite easily. It was advantageous to the masters and the men, and to all concerned, besides there was far less risk of danger, as compared with blasting. He supposed they would all have to be prepared to spend a little extra on ensuring safety now, under the new explosives order, and he was perfectly convinced that at many places this would be the best instrument with which that could be secured. It had not been successful at some places, but the circumstances were not the same. At his colliery the machine did all it could, but it did not break the coal up into small pieces to get it into the tub. That was one of the circumstances that in some places would militate against the introduction of this cartridge, but taking it all in all he could say that where it would act it would act well, and Mr. Tonge had got something which he hoped and believed would eventually do him good.

Mr. Burrows said that he quite agreed with everything that could be said as to the necessity of non-explosives in getting coal, and personally he had spent as much time as anyone in experimenting with that object, but he was afraid the plan suggested would cost them more than the other system. He did not want people to rush into it thinking they were going to save money by it, because they would not. If they fired shots in the day-time they disturbed one half of the place. As had been said, if it was a safer thing they would not look at the cost, but he wished to express his

opinion very strongly that all attempts to do away with explosives meant a great deal more trouble and cost. If Mr. Tonge had solved that question, and had got something better, he should be glad to see it.

Mr. Hutchinson said that they were all prepared to look after the safety of their men, and he should be glad to see anything that would lead to safety and do away with explosives. He should like to know what was the cost of the machine as against explosives, especially in different methods of working. At Hulton Colliery they were placed under favourable circumstances, still he thought Mr. Tonge ought to put the matter in a better light with regard to the cost than he had done. He should like to experiment with the cartridge, and if it was any gain he should only be too glad to use it.

Mr. Wallwork said that when they went away they thought the shots had done the work well, but when the coal came to be filled next day they found it in large blocks, and not parted from the floor. He admitted that they had a bad floor parting, the holing being done next the roof, but he should fancy where the coal was holed in the floor the machine would have a better chance. Where the coal had to be lifted up, and they had a bad floor, it might spring a bit.

Mr. Atherton said that he was using one of the cartridges and had made a series of experiments. It appeared to him that the principal thing was to ascertain how the machine could be worked in different mines. Because it was found to work well in one mine, it did not follow that it would work equally satisfactory in another mine under different conditions. Up to the present he had not got beyond the experimental stage, but he had a great deal of faith in the machine. In their mines it had not worked so well as at Hulton. They had tried it in wide

work and strait work, and sometimes it answered very well, but at other times it did not. He had found there was generally some cause when it had partially failed. In his case it seemed to be a great desideratum that the pistons, instead of travelling an inch should be capable of extending about two inches; in that case he thought it would bring the coal down. He still expected to be able to make it work in their mines. On the ground of safety alone he thought it was a very desirable thing.

Mr. Tickle said that they had tried the machine at the pits of the Abram Coal Company, but they had that failure spoken about by Mr. Unsworth, Mr. Wallwork, and others. Immediately the machine began to work everyone thought there was going to be a successful experiment, the weighting or crushing being great, but when the pistons travelled to a certain point the pressure was liberated and they ceased to act, so that the machine failed to break the coal off; and it had to be brought down by explosives or manual labour. There was one heading in which the coal was holed and had a loose side where the machine brought the coal down. They had tried it in the Arley mine both in the coal and the roof and they had the same experience, namely the coal appeared to be lifted but when the machine was removed and colliers got the coal, it cost them more labour to remove it than it would had the machine not been used. In the roof the machine was a complete failure. A great deal depended on the nature of the mine, and the floor, and the roof. He had no hesitation in saying that under more favourable conditions, no matter whether the coal was holed at the top or the bottom, Mr. Tonge's machine could be applied with success.

Mr. Tonge, in his reply, said that after what had transpired during the past eight months he had greater confidence

in the machine than before, and he was hopeful they would bye-and-bye produce a cartridge that would be able to deal with by far the majority of coals. There was a general idea that the experiments at Scot Lane Colliery were successful, but as to the lifting of the coal he agreed with Mr. Unsworth. He admitted there was a considerable amount of labour to bestow upon the coal after it was lifted and broken, but he could not agree that there was more labour than if the machine had not been used. When they got the pistons lengthened, they would break the coal up more. The object they aimed at was to get rid of explosives, and they were pleased to find that the cartridge was also economical, at Hulton Colliery.

Mr. Saint, in proposing a vote of thanks to Mr. Tonge, said that he had seen the machine at work in the Arley Mine, at Hulton Colliery, and it did the work remarkably well. The coal was holed four to five feet deep, and he saw it in operation on the face about 15 yards long, in which there were about six holes, and the coal was brought down in excellent marketable condition.

Mr. Burrows seconded the motion, which was passed.

ON AN IMPROVED APPLIANCE FOR DRAWING TIMBER IN MINES.

By Mr. D. H. F. Mathews, H.M.I.M.

Prop drawing in mines has always been considered one of the most dangerous operations that the miners have to carry out in collieries; and any apparatus which is more safe and more powerful than the old gablock, or dog and chain, and which will assist in reducing the accidents in mines, and probably lessen the timber cost of a colliery, should be readily welcomed.

I find by Mr. Hall's Reports of the Liverpool District for the last five years there have been twenty-eight fatal accidents from prop drawing, and it appears that only one of those accidents occurred when the gablock and chain was being used at the time. It happens frequently that the gablock and chain is provided for the prop drawer, but he does not always use it, because it causes him a little more frouble and loss of time: and judging the roof to be strong enough to stand, he strikes the prop out with his hammer, when the roof may fall upon him any moment, causing severe injuries, and sometimes unfortunately proving fatal.

The improved appliance, known as the Sylvester Pulling Jack, is the best and safest apparatus the writer is acquainted with for withdrawing props in mines.

It has been in use in North Staffordshire for some time, but has only lately been introduced into a few mines in this district, and is giving great satisfaction. The machine is of very simple construction, being founded on the principle of the gablock or dog and chain. I had the pleasure of seeing it tested first in the Bickershaw 7ft. Mine, at Messrs. Ackers, Whitley & Co.'s Collieries, Leigh, and I was very much struck with the safe manner in which props were withdrawn from old wastes or goaves with its use.

The machine consists (Figs. 1, 2, 3, and 4) of a steel bar 3 feet long, $1\frac{1}{2}$ inches deep, and $\frac{5}{8}$ inch in thickness; having specially shaped notches about one inch apart, $\frac{7}{16}$ inch deep along one edge. A short chain is attached to the bar for fastening it to a firm prop. The notches of this bar form the fulcrum for a 3 feet lever, which is made with a forked end, through which pass two $\frac{7}{16}$ inch bolts, the bolts being placed a little more than 1 inch apart. The bolt which turns in the notches allows the lever to describe an arc sufficient to bring the sliding block to the next notch. The other bolt

connects the lever by means of a link to the block, which slides along the notched bar.

This sliding block serves two important purposes; firstly, it is fitted with a catch bolt which falls at right angles into the notches of the bar holding the block, while the lever reaches forward into the next notch; and secondly, the rear part of the block being formed into a jaw-shaped recess, it allows any link of the chain used for attaching it to the prop to be withdrawn, to be connected and securely held. This prevents, to a considerable extent, the loss of distance along the notched bar when taking hold of a fresh portion of chain, as the length of chain may be easily regulated.

A leverage of 30 to 1 is obtained by Sylvester's Pulling Jack, although only a 3 feet lever is used, which is a great improvement on the old gablock, which on an average is only 7 to 1.

The machine may appear at the first glance to be slow in action by its only moving 1 inch per stroke of the lever, but when we consider that probably one-third or more of the distance advanced by the old gablock is lost again through the springing back of the prop in consequence of having to take hold of a fresh length of chain after each movement, the improved machine has really the advantage in regard to speed as well as being much more powerful.

Fig. 5 illustrates the method of removing a buried prop; also the manner in which the catch bolt of the machine is withdrawn when the sliding block has arrived at the top of notched bar.

The appliance is attached to a firm prop, which may be several feet away from the prop in the waste which requires to be withdrawn, it depends on the length of chain used, the average distance being four to five yards, but I have

Trans. Man. Geol. Soc., Part XV., Vol. XXV.

To illustrate Mr. D. H. F. Mathews' paper.

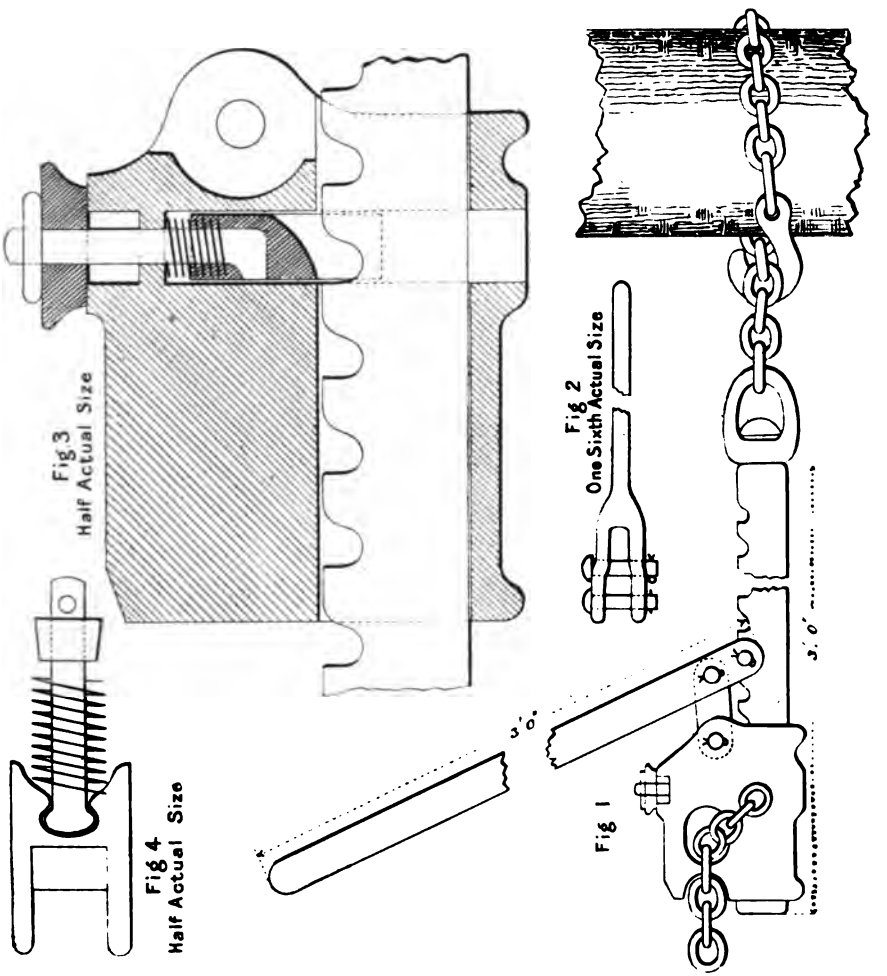


Fig. 5.

seen the machine fixed nine yards away from the props to be withdrawn, and two men were able to get out seven 7-feet props in the one fixing of the machine in thirty-five minutes, and each of those props would cost one shilling each to the colliery proprietors before they were sent down the mine. This will prove that if the machine costs thirty shillings it will soon repay itself in the value of timber to be re-used again, as well as securing greater safety for the men employed in that class of work. The machine has also been found useful in taking old bars out, when they require changing in haulage roads. The machine can be attached to the haulage rope, or to one of the secure props, some distance away from the bar to be withdrawn, which will be found much safer than the old method usually adopted. Sometimes labour and loss of time is caused when trams or tubs are locked together through their breaking away in jigs or endless-rope brows. The pulling-jack in these cases may be hitched to the rails, rope, or chain, and has been found to be of great service. The weight of the machine is only 28 lbs., including the three feet length of chain and hook attached to the notched bar, and can be easily carried by one person. The writer is of opinion that when this machine is more generally used, and a special rule adopted at collieries that no timber must be withdrawn from the wastes or goaves, or working face, or roadways, except by authorised qualified prop-drawers, and then only by means of a gablock and chain, or patent pulling jacks, that accidents occurring from prop drawing in mines will be considerably reduced. I am glad to be able to state that one company in this district has recently adopted rules to that effect, where they have sixteen of Sylvester's machines in use, and they do not allow timber to be knocked out on any account by their prop-drawers. The inventor of the machine is a workman in North Staffordshire; and the writer has written this paper

with the hope that it will assist to bring to the front an apparatus which will be the means of saving life and limb in mines, and has great pleasure in introducing it to the members of the Society.

The PRESIDENT said that he thought they were indebted to Mr. Mathews for calling their attention to what appeared to be a valuable machine for the saving of life and limb and as he made out there was great economy in the use of it.

Mr. HUTCHINSON said that they had introduced the machine at the Bamfurlong Collieries. He had put it into the hands of men who had been drawing timber at least 14 or 15 years, and who were used to the gablock and chain and the ordinary method of drawing props, and they said they could draw 12 to 13 props with the "Pulling Jack" where they could draw six or seven before. Not only that, they said that many props which they would have had to leave in the goaf and which they dared not go in to loosen under the old system, could now be got out by this appliance. He had no need to doubt those statements, and its use meant a great saving to them because every prop cost over 1s. He had ordered several more machines, and in another month they would have 15 or 16 machines in use at their collieries. From the experience he had had he was sure, both in point of safety, and saving to the colliery proprietor, it was the best method of prop drawing.

Mr. TICKLE said that the Abram Coal Company, through the instrumentality of Mr. Alfred Johnson, was the first to use this apparatus in the Wigan district. He had watched it and had been with the men when the machine had been tried. They had used it in the Wigan 4 feet, Wigan 5 feet, and 6 feet, and Orrell 5 feet, and under every possible condition and had found it to answer very satisfactorily.

Objection might be taken to its weight, but it was not very great, and the question became very small when they considered the greater safety of the men when using the apparatus. The difference in weight is 16 pounds, and he contended that was very little when life was at stake. He got a report from one of their timber drawers in the Orrell 5 feet mine. In 7½ hours they took out 200 props and bars, and not one of them cost less than 1s. 3d. each. He considered that was very satisfactory for the time it took to get out the timber. The men took to using the machines better than they did to the old gablock and chain, because they knew they could gain so much more with less trouble and with greater safety to themselves. Experienced timber drawers, having a thorough knowledge of the machine, could so arrange their work that they need be no nearer than ten or twelve feet from the prop which had to be drawn. No hammer is required in the operation, a great point to be considered in timber drawing. He had no trouble at all in getting the men to use the machine, and he had great pleasure in supporting Mr. Mathews's views. They had 21 machines in use, and in fact, they had withdrawn all their old gablocks and chains. They had provided the timber drawer in each district with one of the machines. The Pulling Jack can be applied to many other useful purposes underground, especially in main haulage roads, breakdowns, &c., or for tightening ropes, lifting heavy timbers into position. The machine is very simple, easily handled, and not liable to get out of order. It is bound to come to the front in practical mining work.

Mr. Winstanley proposed a hearty vote of thanks to Mr. Mathews for reading his interesting notes on this machine. He said that he took particular pleasure in doing so, because they had in that particular appliance one of the very few inventions which had been brought out by a man

actually engaged upon the work with which the appliance was connected. They had in connection with the mining industry hundreds of inventions brought out by people who never went down a pit in their lives, and of course it went without saying that those appliances were never successful. He happened to know the circumstances under which this machine was brought out, and it was the result of Mr. Sylvester's careful observation and practical experience. Wherever it had been used it had been found very useful in connection with all manner of heavy colliery work, as well as in drawing timber.

Mr. Unsworth, in seconding the motion, said that he had taken considerable interest in the paper, because it was for the want of an apparatus of that sort that he lost the very first workman who was killed under him. The man was drawing props and he left one in the waste, and he rushed in and knocked it out, which brought the roof down and buried him. He thought at every colliery where they had a hauling apparatus of any kind whatever, the instrument would be very useful in straightening up the road after an accident by withdrawing the tubs and putting them in position where manual force would be of no use whatever.

The President said that no doubt the machine put into use would mean a saving of life and limb as well as economy.

The motion was passed.

Mr. Matthews said that he had brought the subject up from a safety point of view, as when the Compensation Act came into operation it would probably be considered more important as giving greater security whilst performing that class of work in mines.

A vote of thanks to the President closed the meeting.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XVI. VOL. XXV. SESSION 1897-98.

A SPECIAL MEETING of the Members was held at the Owens College, Manchester, 28th January, 1898.

The President, Mr. JOHN RIDYARD, F.G.S., in the Chair.

RECENT ADDITIONS TO THE MANCHESTER MUSEUM.

Professor BOYD DAWKINS, who had undertaken to address the members on the subject of some recent additions to the Museum, said: I do not propose to detain you long with the remarks I have to make, because I feel that the main communication this evening is that which Mr. Bolton is going to lay before us, and which I hope Mr. Dickinson and others will discuss. I merely wish to show some of the additions which have been made to our Museum during the last twelve months to the Geological Collection, with which, of course, this Society is more particularly interested. I do not wish you to carry away the idea that these are all the additions which have been made. They are merely a few of the more interesting, which seemed to me to be appropriate to speak about this evening. First of all we have a very interesting series of minerals and fossils, given to us by Mrs. Alfred Crewdson. They are, some of them, of singular beauty, and they will fill up very large gaps in our

collections. I would ask your attention more particularly to some very curious specimens of the manner in which the remains of animals have become fossilised. Here, for example, is a fossil sea urchin which was originally embedded in the chalk. Inside this sea urchin an accumulation took place, of flinty material, when it was lying loose at the bottom of the sea. There the inner coating was, to a large extent, completed. There was a hollow left, and in that hollow, at a subsequent time, a quantity of flinty material has been formed, in the shape of chalcedony. It is a very beautiful illustration of the manner in which fossils are sometimes preserved. This will give you an idea of one of the sea urchins, which has been converted into silica right through, from one side of the shell to the other. The next specimen which has some sort of relation to the one I have just mentioned is this large hollow ball, which is full of beautiful quartz crystals. This has been merely a hollow in the rock in which the crystals have been accumulated from the outside towards the inside, in the same manner as minerals are formed in a mineral vein; so all these bright glittering points point towards the interior. In this geode the inner layer is, of course, of later formation than the outer.

There is another thing which will interest some here, even more than the specimens already mentioned. Some few weeks ago, a member of this Society, Mr. John Walshaw, was kind enough to send me this specimen of conglomerate, and when I came to examine it I found that it consisted of pebbles irregularly scattered through the mass, and embedded in sand. The pebbles are very curious, being composed of petrified mud. Originally lumps of clay, they had been washed about on a sand bank, as you may see them on any sea beach at the present day, and as I have commonly seen them at Blackpool. They become hardened;

and some of them, I find, are strongly impregnated with iron. These pebbles contain various Coal Measure ferns. How do we know that these pebbles were not perfectly solid before they were washed into the shape which they present now? Simply for this reason—that their surface is pitted all over with little indentations caused by the grains of sand. It is a rough surface, whilst the fracture of the interior presents the ordinary characters of a ball of indurated mud. These pebbles occupy a well defined horizon in the Coal Measures, immediately above the Trencherbone Seam at Tyldesley. I do not know that petrified clay galls have ever before been found in the Coal Measures.

There are here some boulder stones which have been scratched by the action of ice. The interest in them consists in this, that they prove the existence of a boulder clay period—a glacial period, in other words—in Australia, at a period which the Australian Geologists have fixed between the Permians and the Carboniferous of Europe. The evidence is absolute, without any possibility of doubt or difficulty, and the glaciated surfaces on which the stones rest leave no room for doubt whatever; that this is the real explanation of their condition. It is a series which I am very glad to have been able to secure for our Museum.

I have also to call your attention to the big round whorled shells on the table, a series of Ammonites, which I had the good fortune to get some short time ago at Woodford, in Northamptonshire. They represent one of the most handsome species of the Ammonites—*Ammonites serpentinus* which occupies a very definite position in the Upper Lias. It lies about 18 inches above the upper margin of the Marlstone or Middle Lias. They present very curious variations. In one specimen—the largest I have ever

seen—there is a flattening of the outer whorl, which is not evident in the ordinary type of the species. Lastly, we have here a collection of palæolithic implements, found in the neighbourhood of Chard, in Somersetshire, in the river gravels of the River Axe, in a deposit 40 feet thick, which is used for ballast on the London and South-Western Railway. The implements occur, for the most part, at the bottom. At the top others occur which are clearly of neolithic age. We have here one of those places which were occupied as encampments by the ancient palæolithic hunters of the various wild animals then living—the mammoth and the like—and here are the implements which they left behind, made of the chief material of the adjacent upper greensand rocks, and some of them beautifully chipped, and brought to a singularly fine cutting edge. In later times the same spot was selected for a neolithic camp. These are the various matters which I thought it not inopportune to bring before the Society this evening. I wish the Society to realize that the Museum, in the the founding of which it had so great a share, is rapidly growing in interest and importance.

Mr. Mark Stirrup moved that the best thanks of the Society be given to Professor Dawkins for his address. He remarked that what the Professor had shown that evening did not represent a tithe of what came into the Museum in the course of a twelve-month. His view was that anything choice and special which might happen to be in private hands should be given to the Museum, where it would be of more value and interest than if kept locked up in private cabinets. The stone implements which Professor Dawkins had shown them reminded him of some he had seen from the river valleys of Northern France. The position in which they were found closely resembled the valley of the Somme, in which similar weapons occurred.

Mr. Dickinson said he had great pleasure in seconding the vote of thanks. He added: Since the Society's last meeting in this building one of the greatest benefactors of Owens College has passed away—I refer to Mr. Thomas Ashton. When our Society gave its valuable collection of fossils to Owens College there was but a small room for its display, but, mainly through the endeavours of Mr. Thomas Ashton, this palatial wing of the College has since been built, where not only our collection, but the valuable additions which have since come to it, may be seen to advantage. I attended the meeting which was held for obtaining donations towards the building fund, and was much struck with the pleasant way in which Mr. Ashton announced not only his own large benefaction, but the subscriptions of thousands of pounds which followed. Mr. Ashton certainly earned the goodwill of every one so far as I know. His pure faith and noble actions obtained for him the unique position of securing the approval of all parties and sects. That reflection is useful, and may be of value to some of us.

The President, before putting the motion to the meeting, said he thought the Owens College Museum was not sufficiently well known in the district around Manchester, and that if it were better advertised there would be a much larger number of visitors.

The resolution was then passed.

Professor Dawkins in replying said: I am sure it was quite unnecessary to give me these words of thanks. I merely rise to say one thing with regard to Mr. Stirrup's very benevolent words, and his excellent advice to all of us to give our Geological specimens to this Museum; and I really hope that he will set the example by giving us his collection. With regard to Mr. Dickinson's allusion to our

loss through Mr. Thomas Ashton's death, I should like to say that, from my knowledge, and after working here for twenty-eight years trying to get the Museum into proper order, I do not believe the thing would even have been done in this generation but for Mr. Thomas Ashton. We do not owe him our thanks so much for large sums of money which he gave, as for his indomitable energy, and which secured the erection of this building where it was so much needed, and where we are able to meet this evening.

MINERALS FROM THE NICKEL MINES OF SUDBURY, ONTARIO.

Mr. W. E. Hoyle exhibited a collection of minerals from the Nickel Mines of Sudbury, Ontario, Canada, and read the following notes:—

The copper-nickel minerals were obtained from the Copper Cliff Mine, which is one of several works in the neighbourhood of Sudbury, a town situated about 40 miles north of Georgian Bay. It is the junction of the main line of the Canadian Pacific Railway with a branch which leads to Sault Ste. Marie, at the strait connecting Lake Superior with Lakes Michigan and Huron.

The rocks for many miles are Huronian and Laurentian; the intrusive masses are dioritic and the mineral deposits mainly pyrrhotite (a sulphide of iron), containing in places considerable quantities of copper and nickel. It is curious that the pyrrhotite in this region is highly nickeliferous, whilst at Ely, Vermont, the same mineral contains scarcely a trace of the metal.

The ore occurs in pockets of very irregular shape and size, so that it is not uncommon to go in a single blast from absolutely barren rock into first class ore. Copper was

discovered at Sudbury in 1883 and has been increasingly worked—of late years even more as a source of nickel than of copper, the former metal constituting usually 2 to 8 per cent. of the ore and often 30 per cent. of the matt. In order to get rid of the sulphur the ore is roasted in large heaps, which often burn seven or eight weeks continuously, and then reduced in a blast furnace.

In 1894 no less than 112,037 tons of ore were raised, which yielded 2,748 tons of copper, value $195,750; and 2,570 tons of nickel, value $612,724. It is reckoned that about half the nickel used in the world is now supplied by the Sudbury mines.

On the motion of Mr. PLATT, seconded by Mr. W. SAINT, a vote of thanks to Mr. Hoyle for his interesting commuication was unanimously passed.

In reply to Mr. Stirrup,

Mr. HOYLE said the nickel was not deposited in a vein, but in "pockets," or irregular egg-shaped masses. That was the information given him; he did not go down the shaft.

Mr. STIRRUP: Nickel is an interesting mineral from its occurrence in meteorites. It is not so widely distributed as many other metals. There is another region where it is found, and in much larger quantity than in Canada, that is in New Caledonia, from whence our largest supply comes.

Mr. DICKINSON asked whether the "pockets" occurred in any particular strata, in succession, one after the other, as iron ore does in the Forest of Dean.

Mr. HOYLE: The pockets seem to follow each other in an irregular way, because I was told that when one pocket is getting worked out they find out the places where it tails off, and by following these up they are led on to

other pockets. That points to a sort of continuity in the formation of the deposits, but I do not think they are in the same plane.

Mr. Dickinson: In the Forest of Dean iron ore mines there is no layer; you have nothing to do but drive in the level course in a stratum, and when you find the ground beginning to change colour you expect a new "churn" to begin, and it does so.

Mr. Hoyle: I did not find anything like that at Sudbury.

Professor Boyd Dawkins: I may perhaps answer Mr. Dickinson in some way. I cannot help thinking that the nickeliferous ore occurs in a true fissure vein, but irregularly, as is the case in nearly all the mineral veins in Canada. The Huronian and Laurentian rocks are highly altered—so altered that it is very difficult to ascertain whether they have been originally, in some cases, sedimentary, or whether they are crushed crystalline rocks, and the ores—the iron and silver ones—occur in true mineral veins.

THE NOMENCLATURE OF THE SEAMS OF THE LANCASHIRE LOWER COAL MEASURES.

By Mr. Herbert Bolton, F.R.S.E.

Introduction.

The history of this, the Manchester Geological Society, has been in the past bound up with the progress of knowledge of the Lancashire Coalfield.

Its members ought to be, more than any other body of men, most concerned with its continued study and development.

It seems therefore most fitting that this communication should be laid before the Society. Another reason why this paper is laid before you is that the papers of Hall, Looney, Binney, Wild, and Dickinson, and many others recorded in the Society's Transactions, have alone rendered it possible to determine the nomenclature of the coal seams with any measure of success.

The causes which have rendered the preparation of this paper necessary are two; first, the necessity of determining what name out of all those now in use for a single seam should be printed upon the labels of the Manchester Museum when the horizon from which a fossil was obtained is known.

Secondly, it seemed desirable to precede the printing of any one term by the publication of all other terms which may have been or are still in use.

By this means, if a name has been selected which is not familiar to a visitor, a glance at the list of what we consider synonyms will probably tell him whether it relates to a seam of coal he knows by one of the synonyms.

That a coal seam has many names is known to all of you, as well as the fact that the multiplicity of names proves a serious obstacle to investigations upon the persistence, characters, and development of the measures as a whole.

It is even a more serious obstacle to the palæontologist who, being led to assume that two coal seams in different districts are identical because they bear the same name, may, when dealing with the fossils obtained from each, give to those fossils a wider geographical range than they really possess, and also confuse the fauna and flora of one horizon with that of another below or above it.

When an author makes use of a name already in use for more than one coal seam, it naturally follows that readers of his paper assume that the coal seam alluded to is the one

they know by that name, unless it happens that the particular seam is distinguishable by other means.

That the nomenclature of the Lower Coal Measures has been uncertain for fully three-quarters of a century we know from Binney, who in 1839 (*Trans. Manch. Geol. Soc.*, vol. i., p. 77 and 841,) gave three names to the Gannister coal, all of which were then in use.

Two of the three terms given by Binney ("Rabbit" and "Mountain Mine") were known to Elias Hall, and used by him in his "Introduction to the Mineral and Geological Map of the Coalfield of Lancashire," Manchester, 1836, p. 8.

The third term "Gannister" was known to both Elias Hall and Francis Looney, but was only used by them for the grit rock underlying the coal (*op. cit.*, pp. 8 and 27).

The trivial names of "Rabbit" and "Mountain Mine" came into use from the circumstances of the coal being generally worked by levels on the hill sides. (Binney, *Trans. Manch. Geol. Soc.*, vol. i., p. 77.)

One reason, and perhaps the chief, why numerous names have come into use for one coal seam can be found in the conditions under which the Lower Coal Measures occur. A study of the conditions of life in the upland hamlets of Lancashire during the early part of the century may supply another.

The Lower Measures flank the richer middle series throughout the county, and in the northern, eastern, and western areas rise up into moorland hills intersected by narrow valleys.

The coal seams of the Lower Measures crop out in most cases along the flanks of the hills, or even on the summits, hence the use of terms such as those of Elias Hall and Binney, or of such a term as "Pasture Mine" given to a

seam of coal high up in the Lower Measures, which from its position was most likely to be found only on the hills, or along the belt of rough grazing ground called "pastures," which usually separates the grass-land from the moorlands above.

The conditions of life half a century ago were of such a character that local names for coal seams were not only very general, but unavoidable.

The districts were sparsely inhabited, the hill-sides being occupied by widely separated grazing farms, with here and there a small cluster of houses of handloom weavers.

Communication almost everywhere was by means of bridle-paths and "pack-horse roads." Of the inhabitants of one valley and its hill-sides, hardly more than one member was in constant touch with the outer world. A knowledge of what was being done in adjacent valleys or elsewhere was only gained by a long toilsome journey over the moorlands, or by brief conversations between the handloom weavers as they met at long intervals at the house of the cloth master when they delivered a finished piece of cloth, and received a new warp with which to trudge home, and there continue their work.

The farmers often had the right expressly stated in their leases of mining the coal and rock upon their farms or on the moorland above.

Whether they had it or not, however, adits were driven along the line of outcrop of all the chief seams, and the work carried inwards until the collapse of roof or sides, or the accumulation of water led to abandonment and a new excavation elsewhere.

A name was required with which to designate the coal seam worked, and from want of knowledge of the occurrence of the seam elsewhere, or of a name already in use, a local

or trivial name was adopted. Certain examples of these names have already been given, but a still better one is that of "Spanish-juice Coal"* of Mr. John Hall,† a name given by him to the Lower Foot Coal, on account of the resemblance of its fracture to that of a stick of "Spanish juice."

The most fertile source of terms, and we may add of confusion also, has arisen from the fairly general practice of miners and others of designating a coal seam by its thickness as known to them. One result of this has been to create "Yard Mines" in plenty, until the term is now absolutely meaningless. The well-known "Bassy" or "Salts Mine" of Hall, is the "Lower Yard Mine" of Saddleworth and Rochdale, but it is not the "Dirty Yard Mine" of Oldham, which is the next seam above, nor is it the "Yard Mine" of Bacup, for the latter is the Gannister Coal, whilst the "Yard" or "Mountain Mine" of Over Darwen is the 40 Yards or "Upper Mountain Mine." Similarly the "Yard" and "Thin" seams of Hoddlesden Colliery, and the "Yard Mine" of Oswaldtwistle are not the equivalents of the first "Yard Mine" mentioned here, but are held by Mr. Dickinson to represent the "40 Yards" or "Upper Mountain Mine."

The confusion resulting from the use of the word "Yard" is even greater in the case of the Middle Coal Measures, and taking into account the ever-varying thickness of coal seams, and the degree of confusion already existing, it seems better to discard all such terms in the future, and drop as far as possible those already in use.

---

* "Spanish juice" is a black asphaltum-like compound of liquorice breaking with a conchoidal fracture. When boiled with senna leaves and uncrushed linseed, it formed a decoction still held in North-East Lancashire as a valuable specific for cold and bronchial troubles. Mr. Hall, who was eighty years of age when he conducted an excursion of this Society in 1860, and pointed out his "Spanish Juice Coal" to Mr. Binney, was probably as well aware of the qualities of the emulsion as of its characteristic fracture.

† *Trans. Manch. Geol. Soc.*, vol. ii., 1860, p. 87.

The thickness of strata which intervene between one coal seam and another has at times been taken advantage of as the name of a coal seam, and whilst the same arguments can be used against names of this character as in the previous case, these names are of greater value in that they indicate the amount of local sedimentation which took place between the formation of one coal and another, and where the name becomes incongruous by reason of an increase or decrease in thickness of the intervening beds, the incongruity serves to emphasise a point often lost sight of, *i.e.*, the direction from which sediments were brought, and the changing character of those sediments when traced over great distances. The "40 Yards" Coal, or "Upper Mountain Mine," is a good example of such a seam as we have described.

Its position is fairly constant, about forty yards above the Bullion Mine over a wide district, hence the term is well known. At Billinge, however, the two seams are separated by over eighty yards of flags and shales (Hull, *Geol. Surv. Mem.*, "Geology of the Country around Wigan," p. 9, 1862), and the same occurs at other places as at Stalybridge.

It is now a general rule in all scientific writings to adhere to a somewhat rigid interpretation of what has been called the law of priority. Where it can be shown that an author gave a definite name, not already preoccupied, to a species, and sufficiently defined that species, so that it can be recognised by his description or illustration, the author's name is retained, and other names which may have come into use later, from various causes, are regarded as synonyms, and dropped even though they may be in general use.

The determination of synonymy of the many names given to coal seams is a hazardous task, owing to the obscure origin of many of them. Most frequently, names of coal seams have appeared for the first time in literature under

circumstances which indicate that they were already in general use. It is therefore not by any means certain that a name owes its origin to the writer who first published it.

The earliest name given to a seam in the Lower Coal Measures seems to have been that of "Mountain Mine," which was in general use in 1836, when Hall published his geological map, and "Introduction." The term was apparently restricted to the chief coal seam of the series, but from that time on to the present the meaning of the term has extended until the term "Mountain Mine" may mean any of the coals of the Lower Measures.

The term "Mountain Mine" was applied by Hull (*Geol. Survey Memoir*, "Geology of the Country around Wigan," p. 9, 1862) to the coals of the lower measures so early as 1862.

In a similar way the term "Gannister" first used by Phillips for the grit rock underlying the coal we have just spoken of, was also given to the coal itself, which thus became the "Gannister Coal" of Binney in 1841. (*Trans. Manch. Geol. Soc.*, vol. i., p. 77.) The term "Gannister" was afterwards extended by other writers to the whole of the Lower Coal Measures, so that in 1862 we find Hull writing in the *Geological Survey Memoirs*, of the "Lower Coal Measures or Gannister Beds." (*Op. cit.*, p. 9.)

An example of an opposite kind, where a general term has become specialised to one seam, is seen in the use of the term "Rearing Mine."

In 1837, Mr. James Heywood used the word as a general term applied throughout the coalfield to steep mines. (Jas. Heywood, *Brit. Assoc. Report*, Liverpool, 1837, p. 78, and *Proceedings of the Literary and Philosophical Society of Manchester*, 1837, p. 426).

Its use as a general term in the Burnley district is mentioned so lately as 1875 (Hull, *Geol. Survey Mem.*, "Geology

of the Burnley Coalfield," p. 65,) yet Mr. Binney in 1860 used it as strictly applicable to the "Mountain Four Feet," or the united Gannister and Bullion Mines (Binney, *Trans. Manch. Geol. Soc.*, vol. ii., p. 76.)

The utility of these early names was diminished by laxity of use, and it is therefore not surprising to find that in process of time qualifying prefixes were added to each of the general terms in order to indicate more clearly what seams were meant. In this way arose such terms as Upper, Middle, and Lower Mountain Mines; Upper and Lower Foot Mines, &c.

Any attempt to set up the older terms would end in failure, because they were not sufficiently distinctive of any one seam.

It would seem much better, and certainly is more feasible, to advocate the retention of the modified older terms which are now fairly well understood, re-defining their meaning and application, and strive to extend their use, and the abolition of all other terms now applied to the same seams.

COAL SEAMS CONSIDERED IN DETAIL.

FIRST COAL. Hull, 1864.

1841.—*A nine-inch coal* resting upon a shale floor a yard in thickness, and immediately above the Rough Rock. Locality not stated. Binney, *Trans. Manch. Geol. Soc.*, vol. i., p. 78.

1860.—"At a distance of ten yards above the Feather Edge Coal is a *little coal of ten inches.*" Occurring near Barlow's-o'th-Coal Pits in Pilsworth; "by the side of the turnpike road half-way between Bury and Middleton; at Boar Edge, near Bury; and on Wetley Moor, Staffordshire." Binney, *op. cit.*, vol. ii., pp. 80, 81.

1860.—*Foot Coal* of Binney, ten inches in thickness, lying about eight yards above the *Feather Edge Coal* at Boar Edge, near Bury. Binney, *op. cit.*, vol. ii., pp. 87 and 88.

1862.—*Foot Coal of Dulesgate.* Binney, *op. cit.*, vol. iii., p. 327.

1864.—"At Wolstenholme . . . . there is a *coal about nine inches thick* which lies about twelve yards above the three-quarters (Feather Edge or Sand-rock) Mine." Dickinson, *op. cit.*, vol. iv., p. 161.

1864.—*First Coal of Turf Hill and Stalybridge.* "This little seam occurs immediately above, or within a few feet of the Rough Rock." "It may be seen in a lane and brook-section, at a hamlet called Binns, east of Tunshill. Here, indeed, there appear to be two thin seams, ... the upper 18 inches, the lower 6 inches in thickness." Hull, *Geol. Surv. Mem.*, "Geology of the Country around Oldham," pp. 16, 17. "At High Thurston Clough, and Wall Hill, near Dobcross." *Op. cit.*, p. 17.

1864-5-6.—*A thin coal (Swinden Coal)* of inferior quality, lying above the Rough Rock. It has been worked on Great Edge, in the Swinden Valley, where it is 18 inches in thickness. J. Whitaker, *Trans. Manch. Geol. Soc.*, vol. v., p. 96.

1875.—*A ten inch coal seen* in a brook course, east of Hurst House, Delf, Heskin, in the Chorley District. Hull, *Geol. Survey Mem.*, "Geology of the Burnley Coalfield," p. 91.

1875.—*A four inch coal* over Rough Rock in Cliviger Section of the Lower Coal Measures. *Op. cit.*, p. 55.

1886-7-8.—"*Ten inches of coal* seen on Brandwood Moor, near Stacksteads, just above Brierley's Coalpit." C. Dugdale, *op. cit.*, vol. xix., pp. 221, 227.

1890-1-2.—*First Coal of Hull*, quoted by G. Wild, *Trans. Manch. Geol. Soc.*, vol. xxi., p. 375. Described as "Foot Coal" in General Section of Lower Coal Measures. *Op. cit.* p. 394.

NOTE.—*The Lower Early Banks Mine* of Stalybridge and Hough Hill, mentioned by G. Wild, and doubtfully correlated by him with the Feather Edge Mine, may possibly represent this seam and the overlying Bassey Mine. See G. Wild, *Trans. Manch. Geol. Soc.*, vol. xxi., plate facing p. 394.

This seam, which forms the true base of the Coal Measures, has oddly enough failed to receive a name which can be at all regarded as distinctive.

The seam was well known to Binney, who gave it a place in his general section of Lancashire strata. By him it was

generally described as a "foot coal," but the term was descriptive rather than substantive. The same may be said of Hull's "First Coal." The general application of "foot" to the two seams immediately below and above the Gannister Mine, preclude the use of Binney's term. "First Coal" is appropriate, if it were always understood that coal seams should be enumerated from below upwards; but this is not the case, for Hull himself, in his "Geology of the Country around Wigan," p. 9, 1862, *Geol. Survey Memoir*, described the Upper Mountain Mine of Billinge as "1st Coal," and counted down from it. We venture to retain the the term of "First Coal" however since it has not been used hitherto as a substantive.

The "First Coal" is remarkably constant, having been noted at places so far apart as Chorley and Stalybridge, Bury and Cliviger. Its uniform occurrence has been noted by Binney, Dickinson, Hull, and Wild.

The seam is unimportant economically, since it rarely exceeds ten inches.

The seam is six inches thick at Stalybridge, and runs up to ten inches as it approaches the western side of the coal-field, whilst to the north at Cliviger it thins away to four inches.

It is not very clear what seam is represented by the Lower Early Banks Mine. The Sandrock or Feather Edge Coal and the overlying Rough Rock are said to be absent at Stalybridge. If this be the case, then the Lower Early Banks Mine must represent one of the seams under the Gannister coal. It would seem at first sight doubtful that it is the First Coal of Prof. Hull, had he not drawn attention to the character of the latter seam at Binns, east of Tunshill. "Here, indeed," says Prof. Hull, "there appear to be two thin seams, which basset on the banks of the new

reservoir, the upper 18 inches, the lower 6 inches in thickness." (*Op. cit.*, p. 17.)

A comparison of Mr. Wild's sections of the Lower Coal Measures at Stalybridge and Hough Hill with those of other districts shows that sedimentation was not so pronounced on the east of the coalfield as elsewhere, the shales and sandstones being thinner. According also to Prof. Hull (*op. cit.* p. 16), the Lower Foot Coal is often absent, so that the Lower Early Banks Mine must be either the First Coal, or the Bassy Mine, or the two united. The indication of the two seams at Binns points to the last conclusion as very probable, and this view I am inclined to accept.

The value of the First Coal as a datum line has not yet been realised, but if it can be shown, as appears likely, that it is in evidence where the Upper Rough Rock is absent, and also constant over the latter, then of the two it will be most useful and reliable

BASSEY MINE. Binney.

1841.—"*Coal* (*Bassey*), never worked in the neighbourhood of Bury. Two feet, three inches thick. The chief mine of New Mills, Mellor, Compstall, and Ludworth." Binney, *Trans. Manch. Geol. Soc.*, vol. i., p. 77.

1860.—*A sixteen-inch coal* at Whaley Bridge and Ludworth. "Appears to be identical with the Salts Mine of Bury." Binney, *op. cit.*, vol. ii. p. 81.

1860.—"*The New Mills Seam*, called by Mr. Hall the "Salts Coal," from its fracturing like Epsom Salts." Binney, *op. cit.*, p. 87.

1860.—*The Salts Mine* occurs on the south side of Birtle Valley, near Middleton. Binney, *op. cit.*, p. 88.

1862.—Occurrence of the Salts Mine in Dulesgate, between the foot coal and the Spanish juice seams. Binney, *op. cit.*, vol. iii., p. 327.

1862.—*The coal* described by Prof. Hull *as nine inch in thichness*, and visible at Tottington, probably represents the Bassy Mine, the next coal above it being the Lower Foot Mine. Hull, *Geol. Surv. Memoirs*, "Geology of the Country around Bolton-le-Moors," p. 5.

1862.—*Lower Mountain Mine* (6th coal) of Hull's section of the Gannister Beds at Billinge. Hull, *op. cit.*, "Geology of the Country around Wigan," p. 10.

1864.—*Second Coal or Lower Yard Mine* in general section of the Oldham district. Hull, *op. cit.*, "Geology of the Country around Oldham," pp. 16 and 18.

1866-7.—The "*Ribbon*" *Coal* of Disley apparently occupies the position of the Salts Mine. *Vide* Binney, *Trans. Manch. Geol. Soc.*, vol., vi., p. 104.

1875.—"At Long Clough there is *a coal seam* only a few feet above the Rough Rock, and therefore near the base of the Coal Measurers. It lies about 55 yards below the Gannister Coal, which crops out on the bank above the brook. The coal is about 18 inches thick and of inferior quality. It is probably the seam known in some places as the '*Lower Yard Mine*,' and called by Mr. Binney in his tabular view of the coals of Lancashire 'the Bassy Coal.'" Hull, *Geol. Survey Memoir*, "Geology of the Burnley Coalfield," p. 60.

1886-7-8.—*Lower Yard Mine* of Wicken Hall Clough, Saddleworth. W. Watts, *Trans. Manch. Geol. Soc..*, vol. xix., p. 53.

1886-7-8.—*Coal or Bassy Mine* (Lower Yard Mine of Saddleworth.) Two feet thick in Rossendale. C. Dugdale, *op. cit.*, pp. 220, 226.

1890-1-2.—*Lower or Dirty Yard Coal*, and Yard Mine. Wild, *op. cit.*, vol. xxi., p. 375.

1892-3-4.—"*Shale Bed*" seam of the Rishton Colliery, near Blackburn. "I consider this 'Shale Bed' is the 'Salts' or 'Bassy Mine' of Mr. Binney's section." P. W. Pickup, *op. cit.*, vol. xxii., p. 237.

This seam is remarkable in many respects; it ranges over the whole coalfield, and was, I believe, recognised by Binney in Staffordshire. Throughout the coalfield its thickness is usually about three feet, and in nearly all cases the coal is of inferior quality and passing into shale. The sectional block of this seam, presented to the Manchester Museum by Mr. William Pickup, of Rishton, is an excellent example of its usual character. A portion of the coal, usually the lowest part of the seam, is fairly good, but it passes upwards into a curious alternation of coal and shale bands, until the

latter predominates to the complete exclusion of the coal. The term, "Shale Bed Seam," of Mr. Pickup is a very apt and descriptive one.

Although several names have been given to the seam, but three are in general use, and need to be considered as worthy of retention. The term "Bassy Mine," which is perhaps in most use, was probably never intended by its author as a name at all.

The first mention of the seam which I have found is that by Binney, *Trans. Manch. Geol. Soc.*, vol. i., 1841. It is here described as "Coal (Bassy);" the inclusion of the word "Bassy" in brackets plainly shows that it was intended as descriptive merely of the inferior quality of the coal. Another proof of this is the constant use of Mr. John Hall's name of "Salts Mine" by Binney (*op. cit.*) when describing either the coal or its occurrence. "Salts Mine" certainly has priority, but the difficulty of securing its adoption in place of "Bassy Mine" is too great to be easily got over. During the last ten years the term "Lower Yard Mine," formerly restricted to the Saddleworth district, has often been used, but its adoption cannot be supported or recommended for reasons which I have already dealt with. I am of opinion that where possible the seam ought to be designated as the "Salts Mine" of Hall, and failing that, as the "Bassy or Salts Mine."

The term "Salts Mine" was given by Hall, according to Binney, because of a similarity of fracture of the coal to that of Epsom Salts.

(LOWER) FOOT MINE. Binney.

1841.—*Coal* (*Foot Mine*), Principal mine of Quarlton and Affeside. Binney, *Trans. Manch. Geol. Soc.*, vol. i., p. 77.

1860.—Binney, in his second paper on the "Fossil Shells of the Lower Coal Measures," expresses a doubt whether the Bullion Coal

of Burnley was identical with the foot mine of Doghill near Oldham, and that it might eventually prove to be equivalent to the Darwen and Quarlton seam (*i.e.*, the Lower Foot Mine), lying about ten yards below the Gannister Coal. Binney, *Trans. Manch. Geol. Soc.*, vol. ii., p. 82.

1860.—"We saw at Chesham Brook, near Summerseat, the *Quarlton and Darwen Mine* called by Mr. Hall the *Spanish juice Coal.*" Binney, *op. cit.*, vol. ii., p. 87.

1860-1-2.—*Spanish juice Seam*, recognised at Dulesgate by Binney, *op. cit.*, vol. iii., p. 327.

1862.—*Lower Foot Mine* at Affeside Colliery, as determined by Mr. Binney. Hull, *Geol. Surv. Mem.*, "Geology of the Country around Bolton-le-Moors," p. 5.

1862.—*Coal (5th Coal)** of Billinge. Hull, *op. cit.*, "Geology of the Country around Wigan," p. 10.

1862-3-4.—*Lower Foot Coal* of Hartshead, Mossley. Dickinson, *Trans. Manch. Geol. Soc.*, vol. iv., p. 160.

1862-3-4.—"*Half Yard Mine*," of Crompton, near Oldham, *op. cit.*, p. 160.

1862-3-4.—*Lower Foot Coal* of Bamford and Ashworth, and of Whitworth and Bacup, *op. cit.*, p. 161.

1862-3-4.—"*Spanish Juice or Half Yard Mine* at Carr Knol, near Oldham." Binney, *op. cit.*, p. 230.

1864.—*Lower Foot Mine*, in general section of Lower Coal Measures. Hull, *Geol. Survey Memoir*, "Geology of the Country around Wigan," pp. 16 and 18.

1866-7.—*Lower Foot Coal* at Oaken Clough, Bacup, and at ending near Rochdale. J. Aitken, *Trans. Manch. Geol. Soc.*, vol. vi. p. 24.

1866-7.—*Stinkard Seam* of Disley. Binney, *Trans. Manch. Geol. Soc.*, vol vi. p. 104.

1886-7-8.—*Lower Foot Coal* in Rossendale. C. Dugdale, *op. cit.*, vol. xix., pp. 220, 225.

1889-90.—*Lower Foot Coal* at Over Darwen. R. Walkden, *op. cit.*, vol. xx., p. 461.

1890-1-2.—*Lower Foot Coal* at Crompton Moor, near Oldham, and at Colne, Rishton, Bagslate, near Rochdale, and Baxenden. pp. 375, 376.

---

* The position of this seam under the Gannister Coal agrees with that of the Lower Foot Mine, but is not so stated by Prof. Hull.

The oldest term applied to this seam is that of "Foot Mine," given in 1841 by Binney.

Its conversion into Lower Foot Mine has probably been the result of the need to distinguish between it and the Upper Foot or Bullion Mine.

We have already alluded to the name of "Spanish juice Mine" given by Elias Hall, so that no further comment is necessary.

The "5th Coal" of the Billinge section (Prof. Hull, *Geol. Survey Memoir*, "Geology of Country around Wigan," p. 10, 1862,) agrees in position with the Lower Foot Mine, but this fact is not mentioned by Prof. Hull, nor is the seam correlated. The term "Half Yard Mine" has long been in general use in the Oldham district, but its continuance is undesirable.

The "Stinkard Seam" of Disley was correlated with the Lower Foot Mine, and the former term is therefore a synonym.

The term "Lower Foot Mine" is known over the whole coalfield, and no confusion is likely to follow its continued use.

Lower Mountain or Gannister Mine.

1836.—*Rabbit or Mountain Mine* of Elias Hall. "Introduction to the Mineral and Geological Map of the Coalfield of Lancashire," by Elias Hall, Manchester, 1836, p. 8.

1836.—*Mountain Mine of Looney*, in "List of Organic Remains, &c., and where found, to accompany Elias Hall's *Introduction and Map*," p. 26.

Note.—The "List" is incorporated with the Introduction, the pagination being continuous.

1841.—*Gannister Coal*, often called the "*Rabbit*" or "*Mountain*" *Mine*. Binney, *Trans. Manch. Geol. Soc.*, vol. i., p. 77.

1841.—*Mountain Mine* of Looney identified with *Gannister Coal*, *op. cit.*, p. 84.

1841.—"*The Rochdale or Gannister Coal* lying at Birtle Dean." Binney, *Trans. Manch. Geol. Soc.*, vol. i., p. 87.

1860.—(Non) *Gannister Coal* of Dulesgate. NOTE.—Correlated by Binney with the coal at Mr. Dearden's Colliery in Dulesgate, the latter is however the Mountain Four Feet. Binney, *Trans. Manch. Geol. Soc.*, vol. ii., p. 81.

1860.—*Gannister Coal* of Birtle Colliery and Birtle Valley, near Brooksbottom, *op. cit.*, p. 88.

1860-1-2.—*Lower Mountain Mine* of Dunkenhalgh Park, near Church. Mr. Farrimond, *op. cit.*, vol. iii., p. 32.

1862.—*Mountain Mine* of the Bolton District. *Vide* Hull, *Geol. Survey Memoir*, "Geology of the Country around Bolton-le-Moors," p. 5.

1862.—*Mountain Mine represented by two seams* at Doffcocker Colliery, near Bolton. *Op. cit.*, p. 6.

1862.—*Gannister Coal* (*4th Coal*) of Billinge. Hull, *Geol. Survey Memoir*, "Geology of the Country around Wigan," p. 10.

1862-3-4.—"*Gannister*," a term applied by Dickinson to the Lower Mountain Mine, *op. cit.*, vol. iv., p. 159.

1862-3-4.—*Mountain, or Three-quarter Mine* of Hartshead, Mossley, *op. cit.*, p. 160.

1862-3-4.—*Mountain Mine* of Crompton, Bamford, and Ashworth, near Oldham, *op. cit.*, p. 161.

1862-3-4.—*Yard or Main Coal* of Bacup. Dickinson, *Trans. Manch. Geol. Soc.*, vol. iv. p. 161.

1862-3-4.—*Lower, Seventy Yards, or Half Yard Bed* of Over Darwen. *Op. cit.*, p. 162.

1862-3-4.—*Gannister Coal* at Dunkenhalgh Colliery. *Op. cit.*, p. 166.

1862-3-4.—"*The Mountain or Gannister Coal* of Oldham is the *Main bed* of Bacup." Dickinson, *op. cit.*, p. 194. Discussion on Mr. G. Wild's paper: "On the Fulledge section of the Burnley Coalfield."

1864.—*Gannister Coal or Mountain Mine*, in general section of the Lower Coal Measures of the Oldham district. Hull, *Geol. Survey Memoir*, "Geology of the Country around Oldham," p. 16.

1864.—Range of *Gannister or Mountain Mine*. *Op. cit.*, p. 18.

1866-7.—*Sweet Seam* of Bowstones, near Disley, correlated with a seam (Gannister) at Burnley, which unites at the latter place with the Upper Foot Mine above it, *Trans. Manch. Geol. Soc.*, vol. vi. p. 104.

1864-66.—"The *Gannister or Mountain Mine* is generally known in the neighbourhood of Bacup as the *Yard Mine*." J. Aitken, *Trans. Manch. Geol. Soc.*, vol. v., p. 186.

1875.—(Non.) *Gannister Coal or Mountain Mine* in general section of the Lower Coal Measures, Cliviger. Hull, *Geol. Survey Memoir*, "Geology of the Burnley Coalfield," p. 55.

NOTE.—(The so-called Gannister Coal of Cliviger, and the whole of the Burnley district is the Mountain Four Feet, *i.e.*, the Gannister and Bullion Coal seams united.)

1875.—(In part) *Gannister Coal* or *Mountain Mine* of Prof. Hull. *Mem. Geol. Survey*, "Geology of the Burnley Coalfield," p. 56.

1875.—*Gannister Coal* or *Half-Yard Mine* of the Darwen district. *Op. cit.*, p. 57.

1875.—*Lower Mountain Mine* of Shackleton Holmes, and Hogshead Collery, Lower Mine of Oaken Clough. *Op. cit.*, p. 60.

1875.—Range through the Bacup district. *Op. cit.*. p. 61.

1875.—*Yard Coal of Bacup.* J. Aitken, quoted by Hull, *op. cit.*, p. 62.

1875.—(Non) *Gannister Coal* of Dulesgate and Green's Clough. Hull, *Geol. Survey Memoir*, "Geology of the Burnley Coalfield," p. 62.

1875.—*Lower Mountain Mine*, or *Gannister Coal* of the Accrington and Blackburn districts. *Op. cit.*, p. 64.

1875.—*Third Coal* of Cherry Tree Works and Mill Hill, near Blackburn. *Op. cit.*, p. 64.

1875.—(Non) *Gannister Seam* of two borings at Northwood Farm, Padiham Heights. *Op. cit.*, p. 67.

1875.—(Non) *Gannister Coal* of Swinden Hall and Caster Cliff Hill. *Op. cit.*, p. 67.

1875.—*Lower Mountain Mine* of Chorley district, and of Charnock Richard and Charnock Green. Hull, *Geol. Survey Memoir*, "Geology of the Burnley Coalfield," p. 91.

1889-90.—"*Lower Mountain Mine.*" "*Seventy Yards Mine*," and "*Half-Yard Mine*" of Cranberry Lane Colliery, Over Darwen. R. Walkden, *Trans. Manch. Geol. Soc.*, vol. xx., p. 461.

1890-1-2.—*Higher Early Banks Mine* of Stalybridge or Hough Hill. Wild, *op. cit.*, vol. xxi. plate opposite page 394.

1890-1-2.—*Gannister Mine* of Meadows Pit, Bacup, erroneously correlated with the "Halifax Hard Bed." R. Kidston, *op. cit.*, p. 416.

This, the chief coal seam of the Lower Coal Measures, has naturally received the greatest amount of attention, and still has a varied nomenclature.

Of all the terms which have been or are in use, the two we use are of especial value, and both are very old. The term "Rabbit" or "Mountain Mine" seems to have been first used in literature for this mine by Elias Hall and Francis Looney. The name, however, is not theirs, but was quoted as one in general use. Its origin is probably to be sought for in the circumstances of hamlet life which we touched upon in the opening part of this paper.

The term "Gannister" was known to Prof. Phillips, but it does not seem to be known if coined by him. Binney quoted Prof. Phillips in 1841, *op. cit*,, the quotation showing that the term was by Phillips restricted to the hard siliceous rock underlying the coal seam, a fact emphasised by Prof. Hull in 1862,—(*Geol. Survey Memoir, Geol. Wigan*, p. 9)—who also states (*Geol. Oldham*, p. 18)—that he found the term in general use in 1864 amongst the colliers from Stalybridge southwards.

The term "Mountain Mine" was used somewhat loosely so long ago as 1837, for in that year, as we shall see later, it was applied by Prof. Williamson to the Bullion Mine. It is scarcely likely that at this time the coal seams were well understood, or their geographical range known, and I am inclined to believe at the very outset the term was a general one, and applied to all workable seams in the hilly districts of Lancashire. As in a case we have already cited, Lower Foot Coal, the term was qualified later by the addition of "Lower," and "Lower Mountain Mine" came into use as distinguished from the "Upper Mountain Mine," applied to a higher seam. With "Gannister" the case is somewhat different, first applied to distinguish a rock, its application

spread to the coal seam, and afterwards to the whole series. It is still used in all three ways, and we are in order if we speak of a "Gannister Rock," or the "Gannister Mine," or even the "Gannister Series," meaning the whole Lower Coal Measures. Its extension to the whole series is most likely due to the fact pointed out long ago by Dickinson—(*Trans. Manch. Geol. Soc.*, vol. iv., p. 161, 1862-3-4)—and others, that a Gannister rock was not peculiar to the seat of the Gannister Mine, but occurred elsewhere higher in the series. The term was applied to the rock very properly irrespective of its position, and since Gannister rock was found both low and high in the Lower Coal Measures, and was absent in the strata above and below, it easily became a distinguishing feature of the series. Some of the terms once in use illustrate the insularity of miners and others, in days when travelling was less general and easy than now, by reason of their strictly local character. Such terms as "Main Coal" and "Sweet Seam" are examples.

Not a little confusion has arisen in respect to the Gannister Mine by reason of its junction with the Upper Foot or Bullion Mine. This union of two seams we shall consider later, but must here draw attention to the fact that at various times the seam of coal formed by the union has been regarded sometimes as the Gannister, and sometimes as the Bullion, most rare of all has it been indicated as a union of the two.

For this reason we may, without exception, when meeting with the terms Gannister Mine, or Bullion Mine, in papers dealing exclusively with the Burnley Coalfield read Mountain Four Feet instead, for over the whole of this coalfield the seams are united. A singular and confusing discrepancy regarding the Gannister Mine exists in Elias Hall's "Introduction to the Mineral and Geological Map." On page 8, Hall describes the Gannister Rock, and says that it is "well

known to be the floor of a good two-feet coal, called the Rabbit or Mountain Mine." Proceeding further, the Gorse Hall Rock is mentioned, and it is said that "at Little End, in Strines Dale, near Oldham, two seams of coal are found *above* this rock; one is one foot, and the other two feet seven inches thick."

Looney, in the same work, page 26, writes as follows: "Under this rock there is a small one-foot coal, and *under* it a small two-feet, known by the name of Mountain Mine."

The difficulty of determining which statement is correct, and what seams are meant, would be considerable had not Looney expressly stated that the two-feet coal was lowest. The three seams lying below the Gorse Hall Rock are in descending order, the 40 Yards, Upper Foot, and Gannister Mines.

The only two of these which agree with Looney's description are the Upper Foot and the Gannister, the latter, as we have already seen, being then known as the Mountain Mine.

The statement made by Hall of these seams occurring over the Gorse Hall Rock at Strines Dale was probably one of those mistakes which happen occasionally to all careful writers. At Strines Dale, as I learn by enquiry to Mr. George Wild, a colliery once existed in which the Gannister was worked. At Sunfield, a little beyond Strines Dale, Mr. Wild tells me that a quarry once existed, yielding flags and paving stones. The Upper Foot or Bullion coal lies below the rock, which may therefore be the Gorse Hall Rock of Hall.

The Gannister seam has a wide range, being found along the whole fringe of Lower Coal Measures which border the margin of the middle series in the west, north, and east of the coalfield. Its quality is usually good, and the thickness fairly constant, averaging about two feet six inches. As the seam lies almost invariably near the surface it has been

mined extensively, especially in the north of the coalfield, where great numbers of ruined and abandoned adits occur on the hillsides.

Upper Foot or Bullion Mine.

1836.—*Foot Coal* of Elias Hall, erroneously said to occur above the Gorse Hall Rock. E. Hall, "Introduction to the Mineral and Geological Map of the Coalfield of Lancashire," Manchester, 1836, p. 8.

1836.—*Foot Coal* of Looney, in "*List of Organic Remains, &c., and where found,*" to accompany Mr. Elias Hall's *Introduction and Map*, p. 26.

1837.—*Mountain Mine*, W. C. Williamson, *British Assoc. Report, Liverpool*, p. 82.

1841.—*Eight inch coal* in general section of the Lancashire Coal Measures. Binney, *Trans. Manch. Geol. Soc.*, vol. i. p. 76.

1841.—Coal seam "worked at Yeadon, Rawdon, and Honsforth, near Leeds; at Baildon and Heaton, near Bradford; at Catherine Stack and Swan Banks, near Halifax; at Bull Houses, near Penistone; and at several points west of Sheffield." Prof. Phillips in *Encyclopedia Metropolitana*, p. 570, quoted by Binney, *Trans. Manch. Geol. Soc.*, vol. i., p. 81.

1860.—*Op. cit.*, vol. ii., p. 74.

1860.—*Pecten Coal* of Phillips, *op. cit.*, vol. i., p. 82; *op. cit.*, vol. ii., p. 75, 1860.

1860.—*Halifax Coal*, Mr. Teale, "On the Fossil Ichthyology of the Yorkshire Coalfield," *Geological and Polytechnical Soc. of the West Riding of Yorks.*, December 5th, 1839. Quoted by Binney, *op. cit.*, p. 83, and *op. cit.*, vol. ii., p. 76.

1860.—*Foot Coal* of Looney, erroneously correlated with the Forty Yards Mine of Burnley and Rochdale by Binney, *op. cit.*, p. 84.

1860.—*The Foot Coal of Looney* is here correlated with the Foot Coal of Doghill, near Oldham, and of Pimbo Lane. Binney, *Trans. Manch. Geol. Soc.*, vol. ii. p., 77. Revised reprint of the paper published in vol. i.

Note.—Mr. Binney for some unexplained reason repeated before the Manchester Geological Society in 1860 the leading details of a paper he had communicated to the same Society in 1840. The correlation of the coal seams is a little different, otherwise the papers are

identical. The papers are "Remarks on the Marine Shells found in the Lancashire Coalfield," *Trans. Manch. Geol. Soc.*, vol. i., p. 80; and "Observations on the Fossil Shells of the Lower Coal Measures." *Op. cit.*, vol. ii., p. 72.

1860.—*Foot Coal* of Doghill, near Oldham, and the railway cutting near Pimbo Lane Station, Upholland. *Trans. Manch. Geol. Soc.*, vol. ii., p. 77.

1860.—*Foot Mine* of Chesham Brook, near Summerseat. Binney, *op. cit.*, p. 87.

1860.—(Non) *Bullion Coal* of Burnley. Binney, *op. cit.*, p. 82.

1862.—*Upper Foot Mine* seen at Lomax Wood Mill, Bury. Hull, *Geol. Survey Memoir*, "Geology of the Country around Bolton-le-Moors," p. 6.

1862.—*Bullion Coal* (*3rd Coal*) in "General Section through the Gannister Beds, Billinge." Hull, *Geol. Survey Memoir*, "Geology of the Country around Wigan," p. 10.

1862.—"*Hard Bed*" seam of Halifax, correlated by Binney with the Bullion Mine of the Burnley district and the Gannister Mine of Dulesgate, Todmorden. *Trans. Manch. Geol. Soc.*, vol. iv., p. 18.

NOTE.—The Bullion Mine of Burnley and the Gannister of Dulesgate form part of the Mountain Four Feet, *i.e.*, the Gannister and Bullion united, but since Mr. Binney was well aware of this fact, we are justified in assuming that he was correlating the "Halifax Hard Bed" with the upper portion of the two seams mentioned; a conclusion which was quite correct. His correlation was based upon the presence of similar "baum-pots" in the *roof* of each seam.

1862-3-4.—*Upper Foot Coal*, in "General Section of the Lower Coal Measures at Hartshead, near Mossley." Dickinson, *op. cit.*, p. 160.

1862-3-4.—*Upper Foot Coal* of Crompton, near Oldham; of Bamford and Ashworth; of Birchinley, Dearnley, and Clegg's Wood, near Rochdale, and of the Wardle and Whitworth valleys to Bacup. Dickinson, *Trans. Manch. Geol. Soc.*, vol. iv., p. 161.

1862-3-4.—(Part) *Bullion Coal* of Towneley Colliery, Burnley. G. Wild, *Trans. Manch. Geol. Soc.*, vol. iv., p. 189.

1862-3-4.—(Part) *Bullion Coal* of Spa, Clough, Burnt Hills, Dodbottom, Townhouse, and Carre Heys. *Op. cit.*, p. 189.

1862-3-4.—(Non) *Bullion or Mountain Four Feet* of Burnley. *Op. cit.*, p. 193.

1862-3-4.—*Upper Foot Mine* of Oldham. *Op. cit.*, p. 194

1862-3-4.—(Part) *Holmes Chapel Mine.* *Op. cit.*, p. 194.

1862-3-4.—*Upper Foot Coal* of Wholau Nook. *Op. cit.*, p. 194.

1864.—*Upper Foot or Bullion Mine*, in "General Section of Lower Coal Measures." Hull, *Geol. Survey Memoir*, "Geology of the Country around Oldham," p. 16.

1864.—*Upper Foot or Bullion Mine*, in section at Broadoak Mill, Bury. *Op. cit.*, p. 16. The seam is said to thin out at Broadbottom. *Op. cit.*, p. 19. At Helpet Edge, Besom Hill, and Stalybridge. *Op. cit.*, p. 19.

1864-66.—*Higher Foot or Bullion Mine* and union with Gannister at Bacup. J. Aitken, *Trans. Manch. Geol. Soc.*, vol. v., p. 186.

1864-66.—*Foot Coal* at Oldham. Binney, *op. cit.*, p. 190.

1866-7.—*Higher Foot or "Spanish Juice Mine."* Aitken, *op. cit.*, vol. vi., p. 26.

1866-7.—*Lower Smut Coal* of Bakstondale and Shrigley Brook, Disley. Stated to be equivalent to the Upper Fort, of Oldham, and other places. Binney, *op. cit.* pp. 103, 104.

1866-7.—*Little Smut Coal* of general section of Coal Measures of the Disley district. Binney, *op. cit.*, p. 105.

1874-5.—*Upper Foot Coal* of Oldham. Aitken, *op. cit.*, vol. xiii., p. 201.

1875.—*Upper Foot Mine* of Littleborough, Wardle and Bacup districts. Hull, *Geol. Surv. Memoir*, "Geology of the Burnley Coalfield," pp. 59, 60, 61.

1875.—*Second Coal* at Cherry Tree Works, Blackburn. *Op. cit.*, p. 64.

1886-7-8.—*Upper Foot Coal* at Rossendale. C. Dugdale, *Trans. Manch. Geol. Soc.*, vol. xix., pp. 220, 224.

1888-9-90.—*Upper Foot* or *Bullion Mine* of Rossendale. Bolton, *Trans. Manch. Geol. Soc.*, vol. xx. p. 215.

1890-1-2.—*Foot Mine* or *Upper Foot* of the Blackburn and Accrington district. Foot Mine above the Gannister Bed, in the districts of Rochdale, Crompton, Oldham and Hartshead, Ashton-under-Lyne. *Op. cit.*, vol. xxi. p. 367.

1890-1-2.—Absent at Rishton, near Blackburn. *Op. cit.*, p. 367.

1890-1-2.—*Bullion Coal* or *Foot Mine*, of Hough Hill, Stalybridge. *Op. cit.*, p. 368.

1890-1-2.—*Upper Foot* or *Bullion Coal*. *Op. cit.*, p. 376.

1890-1-2.—*Little Coal* of the Darwen district. Mr. W. Taylor in discussion on Mr. Wild's paper. *Op. cit.*, p. 399. Compare with Dickinson, vol. iv., p. 163.

The wonderful preservation of plant tissues in the "Bullion" balls which lie in the roof of this seam, and also the rich fossiliferous character of the roof shales, have resulted in considerable attention being given to the mine wherever it has been known to occur.

This seam is undoubtedly the "Foot Coal" of Hall and Looney, and the "Mountain Mine" of Professor Williamson. The earliest use of the term "Upper Foot" that I know of is by Prof. Hull in 1862, but he probably found it already in use. The "Bullion Coal" is an older term and was used by Binney in 1860. It is now in general use.

It is not quite clear what name the Bullion seam goes under in the Darwen district, the correlation of the Lower Coal Measure seams there being a difficult matter.

Mr. Dickinson omits all mention of it from his remarks upon the Darwen district in his paper "On the Coal Strata of Lancashire."

In the discussion upon a paper by Mr. Wild ("The Lower Coal Measures of Lancashire," *Trans. Manch. Geol. Soc.*, vol. xxi., p. 399, 1890-1-2), Mr. William Taylor claimed to have an intimate knowledge of the Bullion Coal in the Darwen district, where he said it was best known as the "Little Coal." He would seem, however, to place the Bullion Coal above the Upper Mountain Mine, though this even is not clear, and in fairness we repeat the printed statement: "There is a fault which runs nearly parallel with the old Roman road from Entwistle, through Black-

snape, nearly to Blackburn. On the west side of this road the Bullion Coal is usually found nine yards above the Upper Mountain Mine." It may be that what is meant is that the Bullion Coal is usually found nine yards above the Upper Mountain Mine, but on the *opposite* side of the fault.

I do not feel justified, however, in reading such a meaning into it, but from a study of the literature alone I am strongly inclined to infer that the 40 Yards or Upper Mountain Mine is not a double seam, but that the lower of the two is the true Bullion Mine, which is approaching the 40 Yards, in a similar way to the approach of the Gannister to the Bullion.

Mountain Four Feet Mine.

1841.—*Gannister Coal* of Burnley and Dulesgate in general section of Lancashire and Cheshire Coalfield. Binney, *Trans. Manch. Geol. Soc.*, vol. i., p. 77.

1841.—*Rochdale or Gannister Coal* of Dearden's Colliery in Dulesgate, *op. cit.*, pp. 87, 88.

1860.—"*Rearing Mine* on the west side of the Burnley basin," and Bullion Mine on the east side. *Trans. Manch. Geol. Soc.*, vol. ii., p. 76.

1860.—*Gannister Coal* of Dulesgate, recognised as formed by the union of the Foot and Gannister seams, *op. cit.*, vol. ii., p. 81, also

1860-1-2.—Vol. iii., p. 327.

1860.—*Bullion Coal* of Holme, Spa Clough, Cloughhead, Carre Heys, and other localities near Burnley, supposed by Mr. Dickinson to consist of the Gannister and Foot Coals united, *op. cit.*, vol. ii., p. 81.

1862-3-4.—Reference to the *Bullion Mine* of the Burnley district and the *Gannister Mine* of Dulesgate, Todmorden. Binney, *Trans. Manch. Geol. Soc.*, vol. iv., p. 18.

1862-3-4.—"*Mountain Four Feet* of Cliviger and all round the northern part (of the coalfield) to Colne." Dickinson, *Trans. Manch. Geol. Soc.*, vol. iv., p. 162.

1862-3-4.—*The Gannister Coal* of four feet thickness at Bacup. Dickinson, *op. cit.*, p. 162.

1862-3-4.—*Bullion Coal* of Burnley, Spa Clough, Burnt Hills, Dodbottom, Townhouse, and Carre Heys. Wild, *op. cit.*, p. 189.

1862-3-4.—*Bullion Coal* of Burnley, supposed to be the equivalent of the Upper Foot and Gannister Coals of Crompton and Oldham. Wild, *op. cit.*, p. 193.

1862-3-4.—*Holmes Chapel Mine.* Wild, *Trans. Manch. Geol. Soc.*, vol. iv., p. 194.

1862-3-4.—*Bullion or Mountain Four Feet* identical with the Main Coal of Bacup. Wild quoted by Dickinson, *op. cit.*, p. 193.

1864-66.—*Five Feet Mine* of Bacup. Aitken, *op. cit.*, vol. v., p. 186.

1866-7.—*Five Feet Mine*, two mile East of Bacup. Aitken, *op. cit.*, vol vi., p. 25.

1866-7.—*Bullion Mine* of Burnley. Binney, *op. cit.*, p. 65.

1875.—*Gannister Coal or Mountain Mine* in the general section of the Lower Coal Measures, Cliviger. Hull, *Geol. Survey Memoir*, "Geology of the Country around Burnley," p. 55.

1875.—Due to union of Gannister and Upper Foot Mine. *Op. cit.*, p. 61.

1875.—In Dulesgate and the Portsmouth Valley. *Op. cit.*, p. 62.

1875.—*Gannister Coal* of Fulledge, Burnley. *Op. cit.*, p. 64.

1875.—*Gannister Seam* in sections of borings at Northwood Farm, Padiham Heights. *Op. cit.*, p. 67.

1875.—*Gannister Seam* of the Colne district. *Op. cit.*, pp. 67, 68.

1886-7-8.—Occurrence at Gorpley Clough and one and a half miles east of Bacup. *Trans. Manch. Geol. Soc.*, vol. xix., p. 225.

1888-9-90.—*Upper Foot Coal* in the Hapton Valley. Wild, *op. cit.*, vol. xx., p. 223.

1890-1-2.—*Mountain Four Feet or Bullion Coal.* Wild, *Trans. Manch. Geol. Soc.*, vol. xxi., p. 366.

1890-1-2.—*Upper Foot or Bullion Coal* of Dulesgate, Burnley and Colne districts. *Op. cit.*, p. 370, and p. 376.

This seam formed by the union of the Gannister and Bullion Mine, along an irregular north-north-west and south-south-east line, a little south of Burnley, stretches under the whole of the Burnley Coalfield, reaching the

surface in the Padiham, Colne, and Portsmouth valley districts. The coal is not so good as that of the two seams before they join, but is much thicker, the seam varying from four to five or six feet. Messrs. Binney, Dickinson, and Wild very early recognised that a junction of the two seams was the most likely explanation of the great thickness of what was regarded as the Bullion Coal of the Burnley district, but the actual demonstration of the line of junction was made by Aitken in 1867, from observations in the colliery at Sharneyford, near Bacup, where the Mountain Four Feet had been worked backwards into the Gannister seam, the Upper Foot or Bullion Mine being lost in the roof. Throughout the Burnley district the seam has been known chiefly as the Bullion Coal, but sometimes as the Gannister. Binney also speaks of it as the "Rearing Mine" of the west side of Burnley, but this was a general rather than a specific term.

Thin Coal above Bullion Mine.

1841.—*Eight Inch Coal* in section of Lower Coal Measures. Binney, *Trans. Manch. Geol. Soc.*, vol. i., p. 76.

1860-1-2.—*A small seam of a few inches* thick, 10 yards above the Gannister (Mountain Four Feet) in Dulesgate. Binney, *op. cit.*, vol. iii., p. 327.

1862.—*Fire-clay Coal* of Upholland (2nd Coal), ten inches thick. Hull, *Geol. Survey Memoir*, "Geology of the Country around Wigan," p. 9.

1866-7.—*A thin band of coal about one inch* thick, occurring in Hoyle Hey clough, Bacup, and very constant over an area of many square miles. Aitken, *op. cit.*, vol. vi., p. 26.

1862-3-4.—*Middle Mountain Mine of Upholland*, correlated by Dickinson with the 40 Yards Mine. *Trans. Manch. Geol. Soc.*, vol. iv., p. 163.

1875.—*Two Inch Coal* in general section of the Lower Coal Measures, Cliviger. Hull, *Geol. Survey Memoir*, "Geology of the Burnley Coalfield," p. 55.

This seam is, notwithstanding its extreme tenuity, very persistent in the Burnley and Rossendale districts. It does not seem to have been recognised elsewhere, with the exception of Upholland, in the Wigan district, where a ten-inch coal, called by Prof. Hull, the "Fireclay Coal" occupies the same position between the Bullion and Upper Mountain Mines. Whether the Fireclay coal is a continuation of the Thin Coal of the Burnley Coalfield or not, the occurrence of a coal seam between the Bullion and Upper Mountain Mines on two sides of the Darwen district, lends additional interest to a right interpretation of what mines are really present there, and what is their true correlation. This question dealt with a little already, we shall have again to consider when discussing the thin coals above the Upper Mountain Mine.

40 Yards or Upper Mountain Mine.

1841.—*Coal* (*Pyritous*) in general section of the Lancashire and Cheshire Coalfield. Binney, *Trans. Manch. Geol Soc.*, vol. i., p. 76.

1841.—(Non) *Foot Coal* of Looney, as concluded by Mr. Binney, *op. cit.*, p. 84.

Note.—Corrected in vol. ii., p. 77.

1841.—*40 Yards Coal* of Rochdale. *Op. cit.*, p. 88.

1841.—*Coal at Dulesgate*, 73 yards above the Gannister Coal. Binney, *op. cit.*, p. 88.

1860.—*Op. cit.*, vol. ii. p. 82.

1860.—*Parron Mine* of Stalybridge. Binney, *op. cit.*, p. 88.

1860.—*40 Yards Coal* of Chesham Brook, near Summerseat. Binney, *op. cit.*, p. 87.

1860-1-2.—*40 Yards Coal* of Dulesgate, Todmorden. Binney, *op. cit.*, vol. iii., p. 327.

1862.—*40 Yards Mine* of the Bolton district. Hull, *Geol. Survey Memoir*, "Geology of the Country around Bolton-le-Moors," p. 6.

1862.—*Upper Mountain Mine* (*1st Coal*), of Hull, *Geol. Survey Memoir*, "Geology of the Country around Wigan," p. 9.

1862-3-4.—*40 Yards Coal* of Bamford, Ashworth, Crompton, Oldham, and of Hartshead Colliery, near Mossley. Dickinson, *Trans. Manch. Geol. Soc.*, vol. iv., pp. 160, 161.

1862-3-4.—*Little, Top, or Half-yard Mine* of Bacup. Dickinson, *op. cit.*, p. 161.

1862-3-4.—*Top Bed* Coal. So termed in the Burnley area. *Vide* Dickinson, *op. cit.*, p. 162.

1862-3-4.—In two seams (*Cannel* and *Black Mines*) at Towneley Colliery. *Op. cit.*, pp. 162, 163.

1862-3-4.—*Yard Coal* and *Little Coal* of Over Darwen corresponds with the 40 Yards Seam. *Op. cit.*, p. 163.

1862-3-4.—*Yard and Little Coals* of the old Hoddlesden Colliery. Dickinson, *Trans. Manch. Geol. Soc.*, vol. iv., p. 163.

1862-3-4.—Divides into a lower *Little Coal* and an upper *Half-yard* seam at Belthorn. *Op. cit.*, p. 163.

1862-3-4.—*Poor Robin* Bed of Brookside and Duckworth Hall *Op. cit.*, p. 163.

1862-3-4.—*Little and Higher Mountain Seams* of Chorley and Heath Charnock. *Op. cit.*, p. 163.

1862-3-4.—(Non) *Middle Mountain Mine* of Upholland and Bispham. *Op. cit.*, p. 163.

1862-3-4.—*Upper Mountain Mine* of Upholland. *Op. cit.*

1862-3-4.—*Higher Mountain Mine* of Duxbury. *Op. cit.*, p. 164.

1862-3-4.—*Top Bed Coal* of Townhouse Colliery, Marsden. Wild. *Op. cit.*, p. 188.

1862-3-4.—*Spa Clough Top Bed* of Towneley Colliery, Burnley. Wild, *Trans. Manch. Geol. Soc.*, vol. iv., p. 189.

1862-3-4.—*Poor Robin Seam* of Church. Dickinson, *op. cit.*, p. 194.

1864.—*40 Yards Mine* of the Oldham District. Hull. *Geol. Surv. Memoir*, "Geology of the Country around Oldham," pp. 16, 19.

1864-66.—*40 Yards Mine* of Bacup. Aitken, *Trans. Manch. Geol. Soc.*, vol. v., p. 186.

1878.—*Op. cit.*, vol. vi., p. 26.

1864-66.—*Upper Smut Coal* of Disley. Binney, *op. cit.*, p. 103.

1875.—*40 Yards* or *Upper Mountain Mine* of Darwen and Oswaldtwistle. Hull, *Geol. Survey Memoir*, "Geology of the Burnley Coalfield," p. 56.

1875.—*Yard Seam* of the Darwen district. Hull, *Geol. Surv. Memoir*, "Geology of the Burnley Coalfield," p. 57.

1875.—*Half Yard Mine* of Copy Nook Coal Pit, Spotland. *Op. cit.*, p. 59.

1875.—*Upper Mine* of Hull. *Op. cit.*, p. 59.

1875.—*Upper Mountain Mine* of Dulesgate and Green's Clough. *Op. cit.*, p. 62.

1875.—*Upper Mountain Mine* of the Accrington and Blackburn districts. *Op. cit.*, p. 63.

1875.—*Yard Mine* of Oswaldtwistle. *Op. cit.*, p. 63.

1875.—*First Coal* of Hull, Cherry Tree Works, Blackburn. *Op. cit.*, p. 64.

Second Coal (Upper Mountain Mine) of Clough Head Coal Pit, Marsden. *Op. cit.*, p. 68.

1875.—*Upper Mountain Mine* in Section of the Lower Coal Measures at Charnock Richard, Chorley. Hull, *Geol. Survey Memoir*, "Geology of the Burnley Coalfield," p. 91.

1880-1-2.—*40 Yard Coal* of Binney. *Trans. Manch. Geol. Soc.*, vol. xvi., p. 125.

1886-7-8.—*40 Yards Mine* over Helpet Edge Rock, near New Hey Station. Watts, *op. cit.*, vol. xix., p. 53.

1888-9-90.—*Yard or Mountain Mine* of Over Darwen. R. Walkden, *op. cit.*, vol. xx., p. 461.

1890-1-2.—*Top Bed* in section of strata at Townhouse Colliery, Colne. Wild, *op. cit.*, vol. xxi., p. 391.

1890-1-2.—*40 Yards or Upper Mountain Mine* of General Section. *Op. cit.*, p. 394.

1890-1-2.—*40 Yards Mine* of the Oldham and Rochdale District. G. Wild, *Trans. Manch. Geol. Soc.*, vol. xxi., *op. cit.*, p. 379.

1890-1-2.—*Upper Mountain Mine* of the Burnley and Accrington District. *Op. cit.*, p. 380.

1890-1-2.—*Upper Mountain or Darwen Yard Mine.* W. Taylor, *Trans. Manch. Geol. Soc.*, vol. xxi., p. 399.

The 40 Yards or Upper Mountain Mine may be looked upon as the highest workable seam of the Lower Coal Measures. It was mined in rude fashion, even more extensively than the Gannister seam in the early days of coal mining, and with the exception of small areas where it lies under a covering of Middle Coal Measures, the great bulk of it has been removed.

The origin of the term "40 Yards Mine" we have explained in the introduction to this paper; the alternative term is a modification of the general "Mountain Mine," to distinguish the seam from the Lower Mountain or Gannister Mine.

The nomenclature of this seam offers no features of interest, except in the Darwen district. Here some confusion exists as to the true correlation of the upper seams, and the nomenclature cannot be determined satisfactorily.

Mr. Dickinson, in his paper "On the Coal Strata of Lancashire," *Trans. Manch. Geol. Soc.*, vol. iv., p. 862-3-4, describes the 40 Yards Mine of Darwen as consisting of two seams, a lower "Yard" and an upper "Little Coal."

"At Belthorn, the upper part (seam) is called the "Half-yard," and the lower the "Little Coal."

"At Brookside and Duckworth Hall they again lie together, and are called the "Poor Robin Bed."

"At Chorley, and also at Heath Charnock, the corresponding coals are known as the Little and Higher Mountain."

Prof. Hull ("Geology Burnley Coalfield," *Geol. Survey Memoir*, 1895, p. 57,) put the Yard seam only of the Darwen District as the equivalent of the 40 Yards Mine of elsewhere, and says "at twelve yards above the Yard seam is a little coal of ten inches resting on a true Gannister floor." In all the details he is in agreement with Dickinson.

As we have already seen (p. 58) the "Little Coal" of the Darwen district is also regarded by Mr. William Taylor as the Bullion seam, but whether the upper "Little Coal" or the lower is meant is not clear. To add to this confusion, neither Dickinson nor Hull mention the presence or absence of the Bullion seam, and the thin coal above it in the Darwen area. The Bullion mine is absent at Rishton, three miles to the N.E. of Blackburn, but the fire-clay seating is present, whilst the second coal of Hull, at Cherry Tree Works, Blackburn, seems to correspond to it. ("Geology of the Burnley Coalfield," *Geol. Surv. Memoir*, 1875, p. 64.) These places are but a few miles away from the centre of the Darwen district, and the presence of the Bullion Mine in one, and its fireclay in the other, indicate a likelihood of its occurrence at Darwen. That the Bullion extends far to the south of Darwen we know from its recorded occurrence at Billinge, north of St. Helens. (Hull, *Geol. Survey Memoir*, Geology of the Country around Wigan, p. 10, 1862.)

Until the district has been examined afresh and more evidence is forthcoming, the question must be left an open one, and the nomenclature given here accepted with some reservation.

Pasture, Bassey, and other Thin Coals.

Whilst the 40 Yards coal is regarded as the uppermost workable seam of the Lower Coal Measures, it is well known that several thin seams are to be found in various districts in the shale between the 40 Yards and the Arley Mines.

The first to be described would seem to be the Bassey Mine of Dickinson (non Binney) occurring at Bamford and Ashworth, near Rochdale, and lying 30 yards over the 40 Yards Coal. (Dickinson, *Trans. Manch. Geol. Soc.*, vol. iv., p. 161, 1862-3-4.)

The same author mentions the existence of a thin coal, called the "Horse-pasture seam," at Towneley Colliery, Burnley, some little distance above the divided 40 Yards Mine. (*Op. cit.*, p. 162.)

The "Pastures Mine" of Wild (*Trans. Manch. Geol. Soc.*, vol. xxi., p. 393, 1890-1-2) is a one-inch coal about 77 yards above the 40 Yards Coal, another one-inch coal with a Gannister seat lying between the two and about nine yards under the Pasture Mine.

The Memoirs of the Geological Survey which relate to the Lancashire Coalfield give a number of sections in which thin coals are shown above the 40 Yards Coal; of these the most important would seem to be in Cliviger, where a foot coal occurs 7 yards above the 40 Yards Coal, and 104 yards higher still, and 23 yards below the Arley Mine, is a "Black Clay Coal" in two thin beds.

By bringing together all the references we have been able to obtain, it will be seen that one, two, or even three coals occur either in close relation to the 40 Yards Coal, or at varying distances above it, along a line drawn from Upholland and Bispham on the south-west, to Colne on the north-east, and that similar thin seams can be traced from Littleborough and Wardle on the north, to Oldham on the south.

Taking the whole of the thin coals to which we have found reference, the following only seem to have received distinctive names:—

The "Bin Coal" of Turton Colliery, near Darwen.

The "Horse-pasture Coal" of Towneley Colliery, Burnley.

Pasture Mines of Wild, and Pasture Mine of others.

The "Black Clay Coal" of Cliviger and Marsden.

The Bassy Mine of the Littleborough and Wardle district.

Whether these thin coals are capable of correlation, we cannot say. Their development along the line mentioned seems to indicate that something might be done in this direction, but for our present purpose, which is the determination of nomenclature only, it will suffice if we point out that the Horse-pasture Seam of Towneley in the Burnley district occupies the same position as the Bassey Mine of the Littleborough and Wardle district, so that one term may prove a synonym of the other. Even if this does not prove to be the case, the term Bassy must be dropped because of its prior occupation and general application to the Salts Mine of Hall.

Conclusion.

After a careful consideration of the many terms local, and other applied to the coal seams of the Lower Coal Measures, those which we tabulate below seem to us the most legitimate to retain. Four of them, it will be noted, and these the most important, are linked together in a most useful way.

Coal Seams of the Lancashire Lower Coal Measures.

Pasture, Bassey, and other thin coals.

40 Yards, or Upper Mountain Mine.

Thin Coal (Fireclay Coal of Upholland).

Upper Foot or Bullion Mine. } Mountain Four Feet
Gannister or Lower Mountain Mine .. .. } where they unite.

Lower Foot Mine.

Bassy or Salts Mine.

First Coal.

If a binomial nomenclature can be got rid of, it ought to be by the suppression of 40 Yards for Upper

Mountain Mine, Bullion Mine for the Upper Foot, Gannister for the Lower Mountain Mine, and Bassy for the Salts Mine.

The succession of seams from above downward would then read thus:—

Pasture, Bassy, and other thin coals.
Upper Mountain Mine.
Fireclay Coal.
Upper Foot Mine .. } Mountain Four Feet.
Lower Mountain Mine. }
Lower Foot Mine.
Salts Mine.
First Coal.

SECTIONS SHOWING THIN COALS ABOVE THE 40 YARDS MINE.

General Section through the Gannister Beds, Billinge.

(Abridged from *Geol. Survey Memoir*, "Geology of the Country around Wigan," p. 10, 1862.) Hull.

	Ft.	In.
Strata	850	0
Upper Mountain Mine (1st Coal)	2	0
Fireclay and Shales	10	0
Coal (Fireclay Coal of Upholland), (2nd Coal)	0	10
Strata	290	0
Bullion Coal (3rd Coal)	0	8
Strata	46	0
Coal (Gannister), (4th Coal)	1	4
Strata	181	8
Coal (5th Coal)	1	3½
Strata	32	0
Lower Mountain Mine (6th Coal)	2	8
Strata	364	0
Millstone Grit	0	0

Section of the Lower Coal Measures at Charnock Richard, near Chorley.

(Abridged from Hull's Section, *Geol. Survey Memoir*, "Geology of the Burnley Coalfield," pp. 91, 92.)

	Ft.	In.
Strata	219	0
Thin Coal	0	7
Strata	48	0
Coal (Upper Mountain Mine) average	2	4
Strata	272	0
Coal, Lower Mountain Mine (Gannister Coal)	1	6

Section at Turton Collery, near Darwen.

(Abridged from Hull's Section, *Geol. Survey Memoir*, "Geology of the Burnley Coalfield," p. 58, 1875.)

	Ft.	In.
Strata	51	0
Bin Coal	0	10
Strata	108	0
Coal	0	10
Fireclay	6	0
Coal, called "Half-Yard Mine"	1	8

Hull states, "It is very difficult to correlate these beds with those of the Darwen district. They are probably not identical." *Op. cit.*, p. 58.

Section of Lower Coal Measures in the Darwen District.

(Hull, *Geol. Survey Memoir*, "Geology of the Burnley Coalfield," p. 57, 1875.)

	Ft.	In.
Coal	0	10
Strata	36	0
Yard Seam (Upper Mountain Mine)	3	0
Strata	210	0
Gannister Coal or Half-Yard Mine	1	6 to 2 ft.

"Besides the above, there is also a coal seam one foot thick, lying 18 yards above the "Half-Yard Mine at Darwen."

Sequence of Strata at Oswaldtwistle.

(Hull, *Geol. Survey Memoir*, "Geology of the Burnley Coalfield," p. 63, 1875.)

	Ft.	In.
Foot Seam of Coal	0	10
Strata	36	0
Yard Mine (Upper Mountain Mine)	3	0

(Absent in some places and irregular in thickness.)

Section in Lower Coal Measures near Blackburn.

(Hull, *Geol. Survey Memoir*, "Geology of the Burnley Coalfield," p. 64, 1875.)

	Cherry Tree Works.			Mill Hill.	
	Ft.	In.		Ft.	In.
Drift and Strata	120	0	....		
First Coal	1	4	....	210	0
Strata	30	0	....		
Second Coal	1	8	....	1	10
Strata	45	0	....	60	0
Third Coal	2	3	....	3	0

Hull supposed the "Third Coal" of this section to be the Gannister.

Sections in Borings at Northwood Farm, Padiham Heights.

(Abridged.)

(Hull, *Geol. Survey Memoir*, "Geology of the Burnley Coalfield," p. 67, 1875.)

	No. 1.			No. 2.	
	Ft.	In.		Ft.	In.
Strata	54	3	....	141	5
Coal	2	2	....	2	0
Strata	36	9	....	34	4
Coal	1	0	....	1	5
Strata	33	6	....	29	4
Coal	0	6	....	0	7
Strata	81	1	....	81	0
Coal (Gannister seam)	4	6	....	3	11

Townley Colliery, Burnley.

(Dickinson, *Trans. Manch. Geol. Soc.*, vol. iv., p. 162. 1862-3-4.)

"In the northern portion (of the Lancashire coaldfield), to which I have referred, the 40 Yards Coal is generally known as the Top Bed.

But at the Towneley Colliery, where the top bed is being worked, it is in two beds, which have been named the Cannel and Black Mines, and there is a thin coal which lies above, called the horse pasture seam."

BURNLEY DISTRICT.

(Wild, *Trans. Manch. Geol. Soc.*, vol. iv., p. 188, 1862-3-4).

Two coal seams between the Bullion and Arley Mines. "The upper (lower) one being 20 inches thick and having a fireclay shale roof, which is the seat of a very thin seam of coal a few feet above it."

SECTION AT FOX CLOUGH, COLNE.

(Wild, *Trans. Manch. Geol. Soc.*, vol. xxi., p. 380, 1890-1-2.)

	Ft.	In.
Strata	4	2
Coal and Smuts of Coal	0	7
Strata	6	3

Op. cit. CLOUGH HEAD, BRIERFIELD.

Arley Mine.		
Strata, with a few thin coal seams	120	0
Coal	2	0
Strata	150	0
Upper Mountain Mine.		
Strata	150	0
Mountain Four Feet (Bullion of Wild).		

GENERAL SECTION OF THE LOWER COAL MEASURES OF CLIVIGER.

(Abridged from Hull's Section, *Geol. Survey Memoir*, "Geology of the Burnley Coalfield," pp. 54, 55, 1875.)

Arley Mine (Middle Coal Measures.)

	Ft.	In.
Strata	690	0
Black Clay Coal, in two beds (6 in. to 24)	1	0
Strata	290	0
Foot Coal	1	0
Strata	21	0
Coal, 40 Yards, or Upper Mountain Mine	2	0
Strata	24	0
Coal	0	2
Strata	99	0
Gannister Coal or Mountain Mine	3	10*
Strata	30	0
Coal, Lower Foot	0	10
Strata	226	0
Coal	0	4
Rough Rock (Millstone Grit).		

* Mountain Four Feet.

Section at Clough Head Coal-pit, Marsden.

(Hull, *Geol. Survey Memoir*, "Geology of the Burnley Coalfield," p. 68.)

	Ft.	In.	
Strata	120	0	
1st Coal ("Black Clay Coal") 18 in. to	2	0	
Various Strata	150	0	
2nd Coal (Upper Mountain Mine) ..	1	5	
Various Strata	150	0	
3rd Coal (Gannister).. .. from 4 ft. to	6	0	Mountain 4 Ft.

Section of Lower Coal Measures at Townhouse Colliery, Colne.

(1870-1-2?—Adapted from Wild's Section, *Trans. Manch. Geol. Soc.*, vol. xxi., p. 391, 1890-1-2.)

	Ft.	In.
Coal	0	9
Strata	15	0
Top Bed Coal	1	0
Strata	147	0
Coal	0	4
Strata	150	0
Bullion Coal (Mountain Four Feet)	4	2

Trawden.

Various thin coals are described by Hull (*Geol. Survey Memoir*, "Geology of the Burnley Coalfield," p. 69, 1895) as occurring in the Trawden valley, but their relation and position are not stated.

Littleborough and Wardle District.

	Ft.	In.
Bassy Mine of J. Dickinson.		
Strata	90	0

40 Yards or Upper Mountain Mine. *Op. cit.*, p. 59.

Bamford and Ashworth, near Rochdale.

(Dickinson, *Trans. Manch. Geol. Soc.*, vol. iv., p. 161, 1862-3-4.)

	Ft.	In.
Bassy Mine.		
Strata	90	0

40 Yards Mine.

Oldham.

(Abridged from Hull's Section, *Geol. Survey Memoir*, "Geology of the Country around Oldham," p. 16, 1864.)

	Ft.	In.
Arley or Royley Mine.		
Strata	14	0
Coal	0	6
Strata	825	0
Coal. 40 Yards Mine	1	4

General Section of Thin Coals of the Upper Part of the Lower Coal Measures.

(Adapted from G. Wild's Section, *Trans. Manch. Geol. Soc.*, vol. xxi., p. 393.)

Royley or Arley Mine.	
Strata	5½ yards.
Two-inch Coal.	
Strata	4 yards.
One-inch Coal.	
Strata	29 yards 1 foot.
Half-inch Coal.	
Strata	134 yards 9 inches.
Pastures Mine.	
Strata	77 yards 2 feet.
Upper Mountain Mine.	

The President moved the thanks of the meeting to Mr. Bolton for his valuable paper. It had, he remarked, always been a difficulty with mining people to know the derivation of the names of different mines. They had in the neighbourhood of Wigan the Ince, Wigan, Pemberton, and Orrell Mines. The explanation of these names was that the particular mine named probably had been nearest the surface in the respective districts, and had been worked—the Pemberton Mine would be nearest the surface, and worked first, in the township of Pemberton. So with the rest.

Then it was pretty well proved that there was a connection between the Wigan Mines and those of Worsley, though, as they were all aware, the names were quite different; what was called the Wigan Nine Feet being called the Trencherbone Mine. He had never heard it explained how that name came to be given to it. With regard to the districts between, he did not think the distance between the Arley and the Mountain Mines had ever been proved.

Mr. Bolton: Mr. Wild's statement is the last, and I think it is that no one really knows.

Professor Dawkins seconded the vote of thanks, which was passed unanimously.

Mr. Dickinson said: I think it is too late in the evening to begin a discussion upon such a wide subject. The field extends over many miles—all the way from Ashton-under-Lyne, by Oldham, Rossendale, Todmorden, Burnley, Over Darwen, Altham, and Accrington, on to Upholland. In a paper which I read to the Society some time ago I gave the names by which the coals were known in the respective districts. It would be very little use calling the mines at Darwen, for instance, by the names which they are known by at Oldham. The Bullion Mine at Oldham is the Upper Foot Mine. It is called the Bullion Mine because of those round bullions occurring in and the flat cakes overlying it. The coal called the Five Feet is sometimes the Four Feet—it is Five Feet at Bacup, and Four Feet at Burnley—and is the Upper Foot Mine and the Gannister Coal joined. I have seen the junction where the one runs down to the other, and they unite to form one seam. Then, if I have gathered the meaning of Mr. Bolton's observations correctly; if it is supposed there are no coal seams intervening between the Arley and the Mountain Mine series of coals, it is a serious mistake. If you examine that section of mine which hangs

in the Geological Museum you will find a section given of a bore hole which was put down below the Arley Mine at Middleton, near Manchester, and there are several seams of coal shown, but none of them workable.

Mr. Bolton: They are mentioned here.

Mr. Dickinson: There is such a long break between the Arley and the Mountain Mine series that a section does not begin consecutively, but there are thin coals lying between the Arley Seam and the Mountain Mine. However, it is too late to enter in such a discussion now.

Mr. Scowcroft: Mr. Bolton's paper has been most interesting to me, and I would offer my tribute of gratitude to him, as, living in the neighbourhood of the Mountain Mines of the Bolton district, I assure you I appreciate his labours. The question is so wrapped in mystery that if one hears it said: "Oh, it's one of the Mountain Mines," no clear understanding is conveyed. To give an illustration of how these various names have cropped up, there is the Doe Mine. At Tonge, to the astonishment of many people we have no so-called Doe about the Five Quarters coal; it is locally known as Bancroft and Little Mine. There are only two pits in Lancashire where the terms are used, and we have lately called it the Doe Mine for the reason that it was time the old names were dropped, to prevent confusion.

Mr. Stirrup: We have in the Society's Library a number of those old maps of Mr. Elias Hall. I suppose they were prepared before he published his large map. Perhaps many of the members may not know that they are his original sketch maps.

Mr. Dickinson: I suppose you know there were more Halls than one?

Mr. Bolton: Yes, Elias Hall and John Hall.

Mr. Dickinson: There was John Hall, of Nangreaves, who gave Mr. Binney much information; he was one of the best geologists of the Lower Coal Measures we had in Lancashire. The other John Hall, who was for many years a member of this Society, was a different person.

Mr. Bolton: That is the Hall of Castleton.

Mr. Dickinson: No; he was connected with Hall, of Nangreaves. I think the map was not by either of these Halls, but by Elias Hall.

Mr. Bolton: That is so. But I did not know there were two Halls of Nangreaves—that is new to me. I would like to say a word upon one point that was raised by Mr. Dickinson, that is, the occurrence of coal seams between those seams generally called the Mountain Mines and the Arley. As I mentioned, such seams do occur. They have been recorded along a line (shown in diagram) stretching from Upholland to Colne; but I have not attempted to correlate them. That was not a part of my task. I have put the sections in the paper so that any one who chooses can work over that district. It had not to be done as part of my Museum work. But the thin coal seams have been recorded and they want working out and correlating. I have put in my paper every reference of Mr. Dickinson in that coal strata map that I possibly could. The reference—page, and title, are all given here.

Mr. Stirrup: Mr. Bolton, as I understand, wants to adopt one distinctive name, in place of all those that refer, in the different districts, to what are believed to be the same mines. The question is whether the plan Mr. Bolton proposes to adopt is a wise one.

Mr. Bolton: That is really the point.

Mr. Stirrup: It would rather be for the gentlemen here,

who are acquainted with these mines, to say whether it would be a wise step to take—to give one name for all these separate districts on the Museum label.

Mr. Dickinson: It would be very desirable if it could be done. The seams are known by different names in different districts, and the leases frequently fix them by the names applied to them in the district. An arbitrary name, therefore, would not be known in the district.

Mr. Bolton: Take the Forty Yards Coal; supposing a specimen was sent to the Museum as having come from the Mountain Mine, which is called by other names in different localities—should I be justified in writing on the label those different names, although they represent one seam in the district? I could, of course, put on record one name by which a particular mine is known, and print that on the label. I refer inquirers to the paper, where the alternative names are given. It would result in our knowing better what fossils are found over a particular coal seam, and we could work out its history better. But the question is—ought one to continue the use of these different names on the Museum label? That is my point. They might still be used in the districts. The best thing in my opinion would be to retain one or at most two terms, and let the rest remain as synonyms.

Mr. Stirrup: We have, as members know, the names in Mr. Dickinson's chart, the names represented in the different districts; but it is difficult to know sometimes where you really are.

The President then moved that the best thanks of this Society be given to the authorities of Owens College for their kindness in inviting the Society to hold this meeting in the College.

The motion was seconded by Mr. STIRRUP, who said that the College authorities gladly welcomed the Society at all times, and the Society was as glad to meet there, in order to show that the members had not lost their interest in the Museum.

The motion was passed unanimously.

Professor BOYD DAWKINS said: It will give me great pleasure to convey your thanks to the Principal, and I would take this opportunity of saying that, before we meet here another year, the electric light will be introduced into the Museum.

This concluded the business of the meeting.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XVII. VOL. XXV. SESSION 1897-98.

The ORDINARY MEETING of the Members was held on Tuesday, February 8th, 1898, at the Society's Rooms, Queen's Chambers, 5, John Dalton Street, Manchester.

The President, Mr. JOHN RIDYARD, F.G.S., in the Chair.

NEW MEMBERS.

The following gentlemen were balloted for and unanimously elected Ordinary Members of the Society :—

Mr. ROBERT ALLEN, 28, Norah Street, Lower Broughton.

Mr. WILLIAM WOODESON, 57, Rosemeath Road, Urmston.

ON THE MINERAL RESOURCES OF THE MIDDELBURG DISTRICT, TRANSVAAL, SOUTH AFRICA.

By Mr. Herbert Lloyd, C.E., M.E.

(Communicated by Mr. William Saint.)

The main subdivisions of South African stratigraphy, as given by Schenck and Green, are in descending order:—

Recent Deposits.
Karroo Formation.
Cape Formation.
South African Primary Formation.

The Primary Formation forms the crystalline floor on which rest the younger sedimentary deposits. It consists of granites, gneisses, and crystalline schists, constituting the major portion of the formation of north-west Central Africa. It occurs largely in Rhodesia, and predominates in the northern and eastern parts of the Transvaal. In the Witwatersrand district this ancient formation emerges from beneath the younger deposits between Pretoria and Johannesburg. As a rule the schists are tilted to a high angle, and show evidence of having undergone considerable contortion; they consist in part of much-metamorphosed beds of sedimentary origin, such as slates, quartzites, and magnetite-quartz rock; but to a greater extent of hornblendic, chloritic, and serpentinous schists that have been derived by mechanical and mineralogical metamorphism from basic igneous rocks (diabases, diorites, and other greenstones).

The Cape Formation.—Lying unconformably on the basement beds are the shales, sandstones, conglomerates, and limestones of the Cape Formation. These varied deposits extend over the southern, western, and middle parts of the

Transvaal. The long range of the Drakensberg consists of these beds, and thus they probably extend to the Cape, and are represented by the grits and sandstones of Table Mountain, and by the shales, sandstones, and quartzites of the Bokkeveldt beds. The fossil evidence afforded by the latter beds indicates an age corresponding to the Devonian and Lower Carboniferous periods.

THE KARROO FORMATION is sub-divided as follows (descending order):—

SCHENCH.		GREEN.
Stormberg Beds (Molteno Beds)	Stormberg Beds	Volcanic Beds. Cave Sandstone. Red Beds. Molteno Beds.
Beaufort Beds		Karoo Beds. Kimberley Beds.
Ecca Beds (including the Dwyka conglomerate)		Ecca Beds. Dwyka conglomerate.

This formation derives its importance for the Transvaal, from the fact that it carries the coal seams which have been the main support to the development of the vast auriferous deposits which have Johannesburg as the principal centre. The coal deposits are confined to the Molteno division of the Stormberg beds.

The rising town of Middelburg is situated between Pretoria and Delagoa Bay, on the Netherland Railway Company's main line. Middelburg is undoubtedly the great centre of the South African coalfields. The coal formation consists of a series of beds of coarse sandstones, shales, and clays, with deposits of coal of varying extent, thickness, and character. This formation, taking the town as a centre, extends about 150 miles to the south-east, about 40 miles to the west, about 45 miles due east, and 10 miles north to the breaking up of the High Veldt. It would not,

however, be practicable to place the whole as coal bearing, owing to the presence of dykes, faults and washouts. The maximum thickness of the measures is about 500 feet, nine seams of coal being frequently pierced in that distance. In some instances, ten seams of coal have been pierced in a distance of 400 feet. We may, however, safely say that the thickness of the coal measures depends entirely on what was the contour of the older formation prior to the deposition of the coal. The beds for the most part are in a fairly horizontal position, and are generally found to rest unconformably on the quartzites and conglomerates which form the gold-bearing rocks of the Witwatersrand. The general conditions under which the deposits exist indicate that the coal is of subaqueous origin, or drift coal. It is generally supposed that the coal was not formed from plants which grew on the spot. In some instances, the outcrop coal is of a better quality than that found at a greater depth, proving that the quality in this district depends on the quality of the plants from which it was formed. Portions of certain seams make a very serviceable metallurgical coke. The quality of the coal varies in different parts of the district, generally becoming poorer as the contour of the country approaches the breaking up of the High Veldt. The surface seams are specially adapted for steam purposes, and will compare favourably with English coal in that respect.

Some of the seams are of excellent quality, and there are few districts in the world where coal giving such a good analysis has been found at such a shallow depth; or where it can be extracted so cheaply. *The Johannesburg Standard and Diggers' News* for May 22nd, 1897, states, on the authority of *The Times* correspondent, that from actual tests submitted the Middelburg coal has a calorific value equal to 95 per cent. of that of Welsh coal. At the

present time most of the coal raised in the district is consumed at the gold mines of Johannesburg, Barberton, and Lydenburg. To the east of the town oil-shale frequently overlies the coal. It consists of fissile, argillaceous layers, highly impregnated with bituminous matter, passing on the one side into common shale, on the other into coal. To the north-east enormous lenticular masses of magnetic iron-ore are met with. The analysis of this ore compares favourably with anything yet discovered. China clay, red marl, and fire-clay are found in large quantities. Middelburg, owing to its natural resources, will probably become the greatest manufacturing centre in South Africa, and it is probable that the various industries will be largely developed in the course of a few years.

The Oliphants River runs north of the town for about twenty miles, where it is joined by the Elands River. Between these rivers lies Mapocks country, and about twenty-five miles further north lies Seccocoeni's country. The rocks of these countries consist of granite, diorite, syenite, silurian, and Lydenburg beds. These districts undoubtedly contain large deposits of gold, copper, lead, and cobalt. Many of the best estates have been secured by British capitalists, and what prospecting has been done is highly satisfactory. Here we find good payable gold, copper, lead, &c., within thirty miles of the great coal and iron centre. These latter districts are in what is called the Bush Veldt. The coal formation is confined to the High Veldt, and runs east, west, and south-east, and north, to the breaking up of the High Veldt, where there is a drop of several hundred feet in the contour of the country; thus, within thirty miles of the coalfield, we find the older rocks exposed. Both districts are found to be highly mineralised throughout. The United African Lands Company have twenty large estates in these districts,

and intend to commence operations immediately on their numerous reefs.

Here, then, at present we have one of the richest districts in the world, containing enormous deposits of coal, iron, gold, copper, lead, cobalt, and clay. Also good markets and railway accommodation. All that at present is required is increased dock facilities at Delagoa Bay. Even with all these proved advantages, there is one point which will probably make the district unique, viz., the finding of the Rand Banket Conglomerate Reefs below the coal measures. These gold-bearing strata, which are found below the coal at Boxburg, have been deposited by means of water immediately on the surface of the granite, which, at the time, must have offered a fairly horizontal surface. These deposits consist of beds of sand and clay, varying in order and thickness, derived from an unknown source. Interleaved among these are the layers of gold-bearing conglomerates, which consist of a mass of water-worn quartz pebbles cemented together by quartz sand, argillaceous matter, and hydrated oxide of iron. Magnetite is often present, and the matrix is frequently porous, sometimes containing breccia as well as pebbles, and is more or less friable. This is the general character of the deposits within the sphere of the oxidising influences of the atmosphere. At the water-level, and sometimes above it, the nature of the banket changes; the colour becomes a bluish or a greenish grey. The limonite and the magnetite are replaced by iron pyrites, and the texture of the mass grows more compact; so that when broken the pebbles are fractured, and the faces presented to view are more even. The pebbles in the different series of the reefs vary in size and composition, and the material of the matrix is not always the same; so that it is often possible, by careful examination, to determine from which reef or series a

particular hand-specimen was derived. For instance, the main reef series can be easily recognised from the nature of its pebbles and matrix. The pebbles of any of the bankets rarely exceed the size of a goose egg, and are usually much smaller. The gold is more or less crystallised, and not water-worn.

After a remote period, during which many thousand feet of these horizontal layers had gradually accumulated, a vast upheaval took place. The volcanic forces, acting below the earth's crust, burst asunder the granite bed and transformed its horizontal floor into the ridge now forming the southern watershed of the Continent. Molten igneous rock also forced its way into the numerous fissures, and overflowed at many points where the dislocation of the earth's crust was most complete. The granite, as it rose, naturally carried with it the overlying strata of sand and clay, the older of which had become transformed by heat and pressure into hard rock, and left the formerly horizontal layers tilted at the angle at which they are now found.

The presence of pyrites in the diorite and the banket indicates a strong solfataric action contemporaneous with or subsequent to the eruption of that rock. It is not likely that the pyrites in the diorite came from one source and that in the banket from another, or that this mineral was deposited at the same time as the pebbles. If it had been there would have been pebbles of pyrites. Crystallised quartz and other crystallised minerals are found in the conglomerate, and they are unquestionably of subsequent origin. All the banket reefs do not carry gold, but most of the ferruginous banket reefs do carry gold, and there is no banket reef bearing any gold which does not carry a considerable quantity of iron in one form or another. There is even in these reefs a close connection between the iron and the gold. The occurrence of magnetite with the

auriferous material is another characteristic which increases the resemblance of these deposits to the ordinary quartz veins. The fact that the gold is found in the banket and not in the sandstone can be accounted for in this manner: the conglomerate beds were naturally more porous and open than the sandstone, and after the upheaval gave easy access to the solution and vapours generated by the diorite eruption. The line of volcanic cleavage can be traced to Klerksdorp on the one side and to Heidleburg on the other. From Heidleburg the reefs are inclined to take a north-easterly direction, and there is every probability of finding them under the coal measures at Bethel and Steenkoolspruit in the Middelburg district. The total output from these banket reefs for 1897 was 3,034,675 ounces of gold. This fact, together with the probability of their lying under the Middelburg Coal Measures, the recent discovery of diamonds between Middelburg and Pretoria, and the present already discovered wealth, speaks volumes for the future success of the district.

The PRESIDENT said all the members would agree that the paper was a most interesting one. It opened to their view a distant part of the world which evidently was very rich in all kinds of minerals. He moved a vote of thanks to Mr. Lloyd.

Mr. STIRRUP said he had pleasure in seconding the motion. There was no doubt that the district described was extremely rich, not only in the precious metals, but also in coal and other minerals, and it only awaited more favourable conditions in order to be fully developed.

The vote of thanks was passed unanimously.

Mr. STIRRUP mentioned that there was present a gentleman who had very kindly brought the beautiful specimens

on the table, and he thought the meeting would be pleased to hear a few words from him.

Mr. Sydney A. Smith (the member referred to) said he had brought the specimens at Mr. Saint's request to illustrate Mr. Lloyd's paper which had been very interesting to him. He had not been in the Middelburg district, but he had travelled through the Transvaal and other parts of South Africa, including the district to the south of Middelburg, and also some of the coalfields, and with regard to the latter one feature particularly struck him, namely, that whilst in England almost universally you find a coal seam lying on a bed of fire clay, in South Africa such a thing had, he believed, not been seen; it was invariably found on a bed of sandstone.

Mr. Stirrup: Do those beds of sandstone contain any rootlets?

Mr. Smith: No—nothing but plain sandstone.

Mr. Stirrup: Free from vegetable matter?

Mr. Smith: Quite free.

Mr. Smith then described the specimens exhibited, which consisted of gold quartz of varying quality, most of them were taken from mines working the main reef series and showed the celebrated "Banket" formation of Johannesburg, and a few from other mining districts in South Africa. In the Rand (Johannesburg) district the general method of treatment of the "Banket" ore was to first crush it in the stamp batteries and then wash it over the amalgamating plates; in this way most of the free gold was extracted by the mercury, the remaining slimes were then taken to large vats and treated with a solution of cyanide of potassium which dissolved and took up the remaining gold, the resulting solution was then passed through a series of boxes containing zinc scrap and in this process the cyanide solution precipitated the gold.

Mr. Dickinson said: There is something for thought in what we have heard. Yesterday I read a report in the *Manchester Guardian* of a lecture given by Dr. Burghardt at Owens College. Dr. Burghardt has been reclassifying the minerals, and coal he does not classify as a mineral; and I was glad to hear Mr. Stirrup just now call it by its proper name—a mineral, which I believe is the legal term for it. Another speaker has said that underneath these coal seams there are no rootlets of *stigmaria ficoides*, nor any of the fire clays which we find in similar situations almost universally in this country. It may be in the recollection of some members that some years ago I exhibited before this Society a number of specimens of coal from Savoy; brought by me from some of the small mines there, and from the interior of the Mont Cenis tunnel, which was then being driven. I examined a large number of the under clays and I did not find a single specimen of *stigmaria ficoides* in any of them. It therefore appears that this South African coalfield somewhat resembles that which occurs in the Alpine ranges of Europe.

Mr. Stirrup: That fact, I think, is well known, for in the coalfields of Central France no underclays with rootlets of *stigmaria ficoides* are met with, and nothing such as we find here at the basement of the coal seams. The difference is accounted for in this way—that, as a rule, in England the carboniferous vegetation grew on the spot where we find it; elsewhere—and especially in France—the vegetation has all been floated into the basins where it is now found in the form of coal.

The President: Mr. Lloyd says in his paper that the coal found in the Transvaal had all been carried by water.

Mr. Dickinson: It did not grow on the spot. Dr. Burghardt lays down a rule that anything which has once lived—

peat, or any growth of that kind—is not to be recognised as a mineral. I am sorry to see these innovations upon established opinions.

A vote of thanks was passed to Mr. Sydney A. Smith for his communication.

NOTES ON ELECTRICAL SHOT-FIRING.

By Mr. H. Bigg-Wither.

In the few remarks I shall lay before you to-day, I do not propose dealing with the history of the application of electricity for the purpose of firing shots, nor with its scientific aspect, but shall confine myself to the practical part of the subject.

The New Mines Order lays down rules not only as to the explosives which may be used, but also the legal methods by which Permitted Explosives may be fired, and in the case of fiery mines it is stipulated that "every charge shall be fired "by an efficient electrical apparatus, or by some other "means equally secure against the ignition of inflammable "gas or coal dust." This restriction as to the method of ignition is, to my mind, perfectly correct, for it would be the height of folly to insist upon safety lamps and Permitted Explosives, and at the same time allow the use of the ordinary tape fuse, which is tantamount to introducing a naked light into the pit, and thus neutralizing all the other precautions introduced in the direction of increased safety in working. I have no doubt that many present have seen the tape fuse not only spit when ignited, but on the explosion of the charge the smouldering fuse has been projected for some distance from the shot, and has brightened

up in its flight through the air to such an extent that it would certainly have ignited gas, if any were present, moreover, if unperceived, it might be left smouldering, until it set fire to the coal itself. As far as my experience goes, I believe that electrical shot-firing is the only practical method which complies with the terms of the Order. I say practical method, because I have had to consider another method, patented by Dr. Carl Roth, by which he generated and conveyed chlorine gas through a fine lead tube to a fuse fixed into a detonator, the chlorine gas ignites a priming in the fuse, which in turn ignites the detonator. This method, although doubtless quite as safe as electric ignition, has the defect of being somewhat complicated, and, at present prices of electric detonators, considerably more costly.

To come to the practical use of electric blasting, you are doubtless aware that there are two systems in vogue, viz., high tension and low tension, the difference is mainly in the form of construction of the fuse.

Fuses.

In the high tension fuse the ignition is brought about by sparks leaping across the two points of the copper conductor where the circuit is broken within the fuse itself; in the low tension fuse this broken circuit is joined by a fine hair-like bridge of platinum or other suitable wire, which is heated to brightness by the passage of the current through it. Surrounding the broken circuit in the high tension fuse and the platinum bridge in the low tension fuse is a sensitive priming composition, which is ignited, and in turn ignites the detonator attached to it. Thus in a complete electric detonator, you have leading wires of a suitable length (usually 48 inches) fixed into an electric fuse, to which is finally fixed the detonator, or, if gunpowder is to be fired, then the detonator is unnecesary.

Exploders.

There are many kinds of exploders in use, but those most commonly used are magneto generators, which are undoubtedly the most reliable. I am not aware that there is any small magneto which will fire both high and low tension fuses, but each class of fuse requires a special exploder. The difference being in the winding of the armature, thus a high tension exploder can be converted by rewinding to fire a low tension fuse, and *vice versa*, at a cost of from 6s. to 7s.

The magneto exploder is almost universally used in firing high tension fuses, but to fire low tension fuses, besides the magneto, both primary and secondary batteries are used in some collieries, preference being given to the latter because they are lighter. For my part, I consider the magneto to be the best for all purposes, as both primary and secondary batteries are very liable to lose power even when not in use, and are responsible for many a missed shot due to the lack of current.

Generally speaking, I am of opinion that it is cheaper in the end to use a well-made magneto with a large reserve of power to ensure firing fuses which happen to be less sensitive than others, and so reduce missed shots to a minimum. The exploders I have referred to are those used in colliery work, where as a rule only single shots are fired. For sinking purposes perhaps the most useful form is the Rack-bar igniting dynamo (weight about 22lbs.) This machine will fire from 15 to 20 low tension fuses simultaneously through a quarter of a mile of twin cable conductors 20 gauge.

Cables.

Properly insulated cable should be used—not bare wires. Several kinds of cable are now used usually of the twin

conductor type. For my part I think two single insulated wires lapped together with a cotton covering makes the most useful and economical cable to use, for the more expensive cables are equally as liable to be cut and are more costly to replace. Some cables are made with conductors formed with several strands of finer copper wire. I think this form of cable is objectionable for use in the darkness of a coal mine, for there is a risk that some of the strands may not be twisted firmly on to the electric detonator wires and if these get into contact with the opposite conductor a short circuit is made with a consequent mis-fire. I may say that cables for firing low tension detonators should have heavier conductors than those used for high tension, particularly if the length of the cable used is considerable, otherwise great loss of power of the current will result.

Mis-fires.

Mis-fires may arise from any of the following causes: damage by cutting or stripping the wires whilst stemming, bad connections, defective exploders or cables, defects in the manufacture of electric fuses. The remedy for all the above causes of mis-fires, except the quality of the electric fuses, lies with the user.

(*a.*) The tamping used should not be of a gritty nature and the wires leading to the fuse should be held firmly along the top of the hole so that there is less risk of the tamping rod damaging them. Electric fuses made with twin leading wires are less liable to be damaged whilst stemming than when two separate wires are used, particularly the thin flimsy wires used in the cheapest make of electric fuse.

(*b.*) All connections should be made by twisting the wires firmly together, after they have been properly cleaned, care being taken that the two leads at their junction with the

cable are properly separated, and are not in contact with earth.

(*c.*) Exploders should always be kept in good repair and scrupulously clean. I have seen exploders sent to us for repair all covered with mud, with the case split and otherwise shewing signs of the roughest treatment. It is hardly reasonable to suppose that so delicate a machine can remain in good working order when subjected to such want of care. A split case, of course, will allow dust and dirt to get inside, which must interfere with its smooth working, and will also cause short circuiting in the exploder itself.

(*d.*) Cables should be periodically examined, and if spliced the joints should be carefully made and properly insulated. Care should be taken never to put them in a hot place where the insulation might get melted.

(*e.*) As regards defects in the electric fuse itself, although at times there have been defective lots, due principally to dampness either in the course of manufacture or storage, still my experience for several years past has been that this delicate article is now manufactured of excellent quality. A colliery friend of mine has kindly given me the following figures, which refer to high tension fuses used at his colliery in six years to end of 1896:—Shots fired 124,781, missed 240, equals 1·92 per 1000. This general average was raised by a defective lot of detonators, the normal average being 1·6 mis-shots per 1000 from all causes. I may as well say here that the best system of recovering a missed electric detonator is to tie a long string to the wires and fasten to a prop, and when the missed charge is blown out it is then easier to find the detonator, and search for it should only be made with the hand, for in using a tool there is the danger of striking the detonator and causing it to explode, with disastrous results should it still lie embedded in the explosive.

Relative advantages of High and Low Tension Fuses.

I have often been asked which system of firing I should recommend. Where single shots are fired I consider either method is equally good, but where a large number of shots have to be fired simultaneously then the low tension system is decidedly to be preferred.

High tension has some practical advantages, as it is possible to test both exploder and cable by passing a current and judging of the condition of both by the strength of the shock. Some people give a preference to Low tension because it is possible to test the circuit in each fuse with a galvanometer and a feeble current, and it is assumed that if the circuit is complete the shot is certain to go off. This by no means follows if there is any defect in the construction of the electric fuse, or a short circuit in the leads.

There is no practical test for a high tension detonator except firing it.

In testing low tension detonators with a galvanometer the detonator itself should always be placed in safety, either in an iron tube or box, so that should the detonator explode it would not harm the operator. Accidents have occurred owing to the cell attachment to the galvanometer being too strong.

Sinking.

For sinking purposes low tension fuses are the best, because, as a rule, several shots have to be fired at once and the complete circuit, connected in series, can be tested before attempting to fire. The fact that the shots can be fired from the surface makes the operation perfectly safe, whereas several serious accidents have happened of late years when firing with tape fuse.

The advantage of firing with tape fuse is that a number of shots can be timed to follow one another in succession, whereas with electrical shot firing, as hitherto practised, all the shots go off simultaneously. I have made some experiments above ground, in order to get the same results, by a combination of electric fuses and different lengths of tape fuse with detonator attached, thus introducing the necessary delayed action of each shot, although all the shots are ignited simultaneously. In this manner I have got off as many as twelve shots in perfect succession, the first shot being the electric detonator, followed by one with three inches of tape fuse, then six inches in next, and so on. To make the ignition of the tape fuse more certain I threaded a strand of guncotton through the top of the fuse, coming out through the gunpowder core. The above is only a rough idea of what is possible in this direction.

I think if you will go into the question of cost you will find that electrical shot firing is nowadays almost, if not quite, as cheap as firing by tape fuse, but, of course, you must deduct the cost of the detonator itself before making the comparison, and only compare the cost of an equal length of tape fuse with the wires and fuse of an electric detonator.

In view of the Explosives in Coal Mines Order of 4th February, 1898, I venture to suggest the following rules, which will of course have to be varied according to the conditions of each separate mine.

Rules for Firing Shots.

1. Shots shall be fired in such mines, in such places, at such times, with such explosives, and under such conditions only as are from time to time authorized by the Manager.

2. All shots shall be fired by a duly authorized Shot-lighter only.

3. The Shot-lighter shall have absolute control over the charging of any shot-holes. He shall carefully examine each shot-hole and if it be found to be irregular or unworkmanlike it shall not be charged. No shot-hole shall be charged where it has been drilled into the "fast" and no explosive shall be forced into a hole of insufficient size. The explosive shall be gently pressed home, not rammed. The first six inches of stemming should only be rammed lightly, but the remainder should be rammed tight. Should the explosive become fast before reaching the bottom of the hole, the hole shall be stemmed up and a fresh one drilled at a distance of not less than six inches from the first.

4. No hole shall be charged in coal unless the holing exceeds three feet in depth and unless the hole is of such depth as will admit of 20 inches of ramming being placed against the charge.

5. Every hole shall be charged by, or under the personal supervision of the Shot-lighter, and no hole shall be charged until he has, with a locked safety lamp, thoroughly examined and tested for gas the place where the shot is to be fired and all contiguous accessible places within a radius of 20 yards, and has found such places free from gas and safe for firing, and has seen that the bratticcs, sheets, and doors are in good order.

6. As a rule only one hole shall be charged or fired in one place at any one time.

7. No coal or coal dust shall be used for stemming. The material used for this purpose should be free from all grit, which is liable to damage the electric wires. Before any hole is charged, any iron or steel pricker, scraper, charger, rammer or stemmer, shall be removed from the place, and nothing but a copper or wooden rammer shall be used in the process of charging or stemming any hole.

8. After firing a shot the Shot-lighter shall examine the brattices, sheets, doors and roof, and also the material blown down, and satisfy himself that everything is safe.

9. No "missed" shot shall be unrammed, but in all such cases a fresh hole shall be drilled, which shall not be within six inches of any hole which has missed fire. In order to avoid the risk of drilling into the charge the direction of every shot hole drilled should, before charging, be marked on the roof with chalk. Should the missed shot contain a detonator, the Shot-lighter shall before firing the fresh hole, attach a string to the fuse of the missed shot and secure it to a prop. Immediately after firing he shall search for the detonator, and until he find it, or is satisfied that it has been exploded by the second shot, shall allow no person to interfere with the coal or other material blown down. He should make the search with his hands only, and no pick or other tool may be used for this purpose. Should the missed shot be not dislodged further holes must be drilled and fired until this is effected.

10. All shots with Permitted Explosives must be fired by electricity. Should a mis-shot occur the Shot-lighter may go to it at once, after first disconnecting the cable from the battery and taking the battery with him.

11. Every Shot-lighter should make the connections with the shot himself, and should have the battery with him at the face while so doing.

12. Batteries should be kept clean and in efficient repair. Cables should be inspected and tested daily before shot firing commences.

13. The explosive used should be carried in a box quite separate from the detonator, and no detonator should be at any time placed on the floor, but should remain in its box until immediately required for use.

I think I have pretty well exhausted my subject, and trust that I have not gone into too many details. I also hope that I have succeeded in putting the important position of electrical shot firing before you in a practical manner.

Mr. Bigg-Wither stated that Mr. Orsman, who had promised a paper on this subject, was prevented from fulfilling his engagement by an accident. The present paper was in substitution of Mr. Orsman's, and at that gentleman's request.

The President said the paper would be most interesting to everyone engaged in the practical work of mining, and he had pleasure in moving that the best thanks of the meeting be given to Mr. Bigg-Wither.

The motion was seconded by Mr. Saint, who spoke of the paper as a very interesting and practical one. It is a subject, Mr. Saint remarked, that will be interesting to the majority of our members, who are engaged in practical mining, particularly in connection with the new explosives order of the Secretary of State. These directions, coming as they do from a man of Mr. Bigg-Wither's experience, will, I think, have great weight. There are many practical points in the paper which are well worth considering and adopting.

The vote of thanks was unanimously passed.

Mr. Bigg-Wither, in acknowledging the vote, said: I hope what I have laid before you may prove of practical use. I have been to places where an electrical exploder had never been seen, and the people expressed astonishment at the rate with which shots were fired by this practical method, quite apart from the question of safety.

Mr. Burrows: I would like to ask Mr. Bigg-Wither why he recommends a low tension for sinking?

Mr. Bigg-Wither: Because of the facility of testing the circuit after you have got a complete circuit made.

Mr. Burrows: Can you test it in any reasonable way?

Mr. Bigg-Wither: Yes, you can do so. This low tension exploder for sinking purposes has attached to it a small testing apparatus; you switch on first of all to "test" and afterwards to "fire."

Mr. Burrows: Is there no risk of the testing firing the shot?

Mr. Bigg-Wither: No, because the current is put through a great resistance.

Mr. Atherton: There are occasional mis-shots with these detonators. Would Mr. Bigg-Wither tell us the best way of dealing with a detonator after a missed shot? When we have one like that we put it under the wheel of a locomotive to destroy it. We do not like to leave them about at all.

Mr. Bigg-Wither: The simplest way is to tie it to another in connection with a battery, and both will go. I have seen a missed detonator put under a locomotive, and run over three or four times, and yet it has not exploded. A detonator which has been at all crushed should be particularly carefully handled, for if a particle of fulminate gets detached the slightest friction upon that will start the whole thing. A damaged detonator is far more dangerous than a whole one.

Mr. Saint: I may mention a very serious accident which happened to a fireman whilst handling a damaged detonator in a colliery in this district. The usual plan was to destroy the missed detonators on the surface, but this man, contrary to instructions, placed one on the rails below

ground and ran a train of twenty-four tubs over it which failed to explode it. Then he picked it up and began to unwind the fuse connections, when it exploded and destroyed three fingers and the thumb of his left hand. They are evidently very dangerous indeed to handle.

Mr. Bigg-Wither: Particularly when they are damaged.

ON THE OCCURRENCE OF SUPPOSED CALCAREOUS TUFA IN THE INTERGLACIAL DEPOSITS OF BLACKPOOL.

By Robert Humphrey, F.S.A. (Scot.).

The North Cliff at Blackpool is composed of interglacial sand and gravel, resting on a more or less exposed bed of lower boulder-clay. The supposed tufa under notice lies principally half-way up the interglacial beds, while a thinner and less important layer is found here and there on the top of the clay from about two hundred yards northward of the indentation at the Gynn.

Here the clay curves upward from the beach to a height of about twenty feet. The layer of supposed tufa is distinctly seen projecting from the top of the clay all along the curve, and some fragments may be found at the bottom of the cliff. It comes into view again two hundred paces from below Uncle Tom's Cabin, and is immediately lost beneath an extensive fall of gravel and sand. At another hundred paces it appears on the top of the clay, and is here about six inches thick. The clay at this part stands nine feet above the beach.

By extending the investigation to half-a-mile further northward, the best development is met with. On the

beach are many large and grotesque blocks and pillars which have fallen from the cliff. I noticed one pillar which measured eight feet in length and about one foot in diameter. The exterior of these fragments has a sandy appearance, but the pillars, when broken, present the hard and compact character of carbonate of lime. They are like stalagmites of peculiar origin.

Observing that the thin layer on the clay could not be the true bed of such large masses as were lying around, I ascended the cliff and found *in situ*, among the gravel and sand, about half-way up, a thick layer perfectly formed with protrusions or pillars of the same character as the debris below.

By zig-zagging up and down the face, I followed the layer until it tailed off to right and left and disappeared. A deposit such as this, associated with boulder-clay and interglacial beds aroused some interest; and seeing that the layer development of it seemed to be among the latter formation, it was there my attention was directed. I had found the matrix of the deposit; it was now necessary to discover the genesis of it.

Following a layer to the right or southward to where it tailed off, a bed of sand was reached whose front was being hollowed out by the wind. On the face of this bed were small projecting knobs and hard spiky substances standing out. Some of these I extracted, and found others to be composed of sand whose particles had been cemented together by some agency. The knobs and spikes were but a few inches in length; the lower part broadening out to a base. The layer of gravel on which they rested was harder and apparently less pervious than that above, and supported an incontinuous and thin bed of matter similar in substance to the upstanding spikes.

My theory on the spot was that both bed and spikes were formed of the sand permeated by carbonate of lime, and a subsequent test with acid confirmed this.

Here, then, in miniature, and in course of formation, as it were, were the pillar-like fragments on the beach and the slabs to which some of them were attached, as well as the origin of the thick layers and protrusions noticed half-way up the cliff.

The Interglacial strata of Blackpool are evidently, in certain places at least, highly charged with carbonate of lime; which, being carried downwards, is arrested when it reaches a layer of unusual compactness, where it forms a stalagmitic bed quite as we are acquainted with this in cave deposits. But all this is accomplished *within* the beds; and it is only when these are exposed by a fall of matter from the cliff that the result of the percolation is revealed.

Once the mass with its imbedding sand is hurled to the beach, the sea attacks the detached fragments; and, quickly clearing away the soft surrounding material, leaves the hard cemented bed and pillars as we now find them.

As to the presence of carbonate of lime in the cliff, the theory might be advanced that it is derived from the abundance of shell fragments in the beds; or it might lead to the possibility of some connection with the limestone region to the eastward in the Settle and Clitheroe districts. It is possible that a lake, highly impregnated with lime may have been formed during the interglacial period on what is now the Fylde.

Calcareous tufa is a well known deposit, and is met with chiefly in limestone districts. According to Sir Archibald Geikie it is also found on the ancient terrace—levels of the saline lakes of Utah and Nevada, where it acts as a cement

to the gravel beds. I find also in Lyell's "Principles" some interesting particulars of it. It appears that so similar in power of endurance as well as in appearance is it to concrete that the houses of Czled, in Hungary, are built of blocks quarried from the bottom of the neighbouring marshes.

But I have met with no mention of it in connection with the cliff of Blackpool; and it would be interesting to ascertain if it has been unrecorded in scientific media, and if it has been noticed in similar strata elsewhere in this country.

That the people of Blackpool have found out the pillars and use them as garden ornaments only conveys to me that the picturesque stalagmitic appearance has been duly appreciated.

As the face of the cliff is being rapidly altered by the various processes of denudation, the conditions which I have sketched will probably alter or pass away, and it is perhaps well that they should be recorded.

The thanks of the meeting having been passed to Mr. Humphrey for his paper,

Mr. Holroyd said: I am very sorry Mr. Humphrey has not brought specimens of the stalactites and stalagmites which he mentions as having found; they would have been the most important evidence he could have brought of finding calcareous tufa in the inter-glacial clays of Blackpool. The evidence, as far as I have seen it, is not as conclusive as I should have liked. The effect of testing the sandstone, with acid, only proves that we still have a kind of limy cementing material present, and does not prove that it is secondary calcareous tufa, which Mr. Humphrey's paper intends us to understand it is. I may say that I consider

myself entitled to speak on this question, for I spent much time in the examination of the glacial clays of Blackpool and its vicinity in search of fossil shells, and I have never seen anything of the nature of calcareous tufa there, though, of course, negative evidence goes for very little. But I may say that we have at Blackpool, and in other Lancashire localities, evidence of submerged forests, and from what I know of submerged forests and old lake-basin deposits in other localities, on the east coast of England for instance—Bridlington, Filey, and further north—I know there are beds of calcareous marl often found accumulated in the inter-glacial clays and gravels; and it is possible some calcareous matter may have been borne from the calcareous marl found in the bottom of these old lake deposits. But that it is actually calcareous tufa, derived, say, from the carboniferous limestone of North Lancashire I can scarcely credit. I am only sorry Mr. Humphrey has not brought the other specimens with him, so that we might have had some further evidence on the matter. At present I must keep an open mind with regard to the subject of the paper.

Mr. Barnes: Has any chemical analysis been made of this substance?

Mr. Humphrey: No.

Mr. Barnes: Because to my mind 80 or 90 per cent. of it is silica, and there is very little lime at all. Calcareous tufa consists of 99 per cent. of calcium carbonate, and not of silica. This seems to be a deposit of sand subsequently consolidated by infiltration of calcium carbonate in solution. It would be well to have it analysed. Calcareous tufa as found in limestone districts is very different in appearance from this; it has no quartz grains in it.

Mr. Stirrup: I would like to say, as Mr. Humphrey asked whether this subject had previously been brought

before the Society, that I brought it before the Society many years ago, and I exhibited similar specimens to those which Mr. Humphrey has laid before us *(Trans. Man. Geol. Soc., Vol. XVII., p. 291, 1884)*. It is not at all an unknown deposit; it has been known for a long time, for, as Mr. Humphrey says, there are evidences of it in all the garden decorations in the district; and you may see also large blocks upon the sea shore. It is, however, well that the matter should come before us from time to time, inasmuch as the face of the cliff is constantly changing, owing to the action of the sea. At the time I am speaking of, now many years ago, in the cliffs on the sea-shore and lying on the top of the lower boulder clay there was to be seen a ripple-marked consolidated sandstone bed several inches thick. The sea had washed away the clay from underneath this bed of sandstone, which stood at the height of several feet above the shore line, and there was quite a cave underneath. I consider that all these masses are simply drift sands, which have been hardened by the infiltration of carbonate of lime—and possibly of silica also—in solution, the lime having been obtained doubtless from the numbers of shells which are found in the sands above. That it is calcareous tufa I do not see that there is any evidence whatever. I agree with Messrs. Holroyd and Barnes that it is distinctly different from calcareous tufa, as we know it; and I am of opinion that it is simply the remains of an old sea beach, where the ripple-marked sand has become hardened. I nevertheless think our thanks are due to Mr. Humphrey for bringing the subject before us.

Mr. Dickinson agreed with Mr. Stirrup that the Society's thanks were due to Mr. Humphrey. Most of us (Mr. Dickinson said) have seen these masses of stone in the gardens and churchyards about Blackpool, and I was rather surprised to hear them called tufa. I have always put them

down as siliceous or calcareous aggregations. If you look carefully you will see in the larger of the specimens which Mr. Humphrey has brought that it takes a stratified form. It is stated that similar aggregations have been found in some of the continental salt fields. There is little doubt that both South Shore and Blackpool are a continuation of the salt field which extends from those old salt meres at Barton, a little south of Birkdale, and on to Preesall, near Fleetwood. Anyone who has carefully observed the shore at South Shore will have seen that peat beds have actually settled down to low water mark; and it is recorded that within the present century the cliffs of Blackpool extended out to the mussel beds, about a third of a mile west of Uncle Tom's Cabin. The associations altogether of the salt field seem to show that these are saline aggregations in some form.

Mr. Humphrey, in acknowledging the thanks of the meeting, said: The chief object in bringing this paper before you was to gather information for myself. I have learned from the various speeches much that I did not know before, and it seems to me I should have put a point of interrogation after "calcareous tufa," at the head of my paper. I am certainly much indebted to the members for their criticism of the paper, and I feel, for myself at any rate, that it has not been written in vain. I may say that I had looked through your Transactions, but failed to find any reference to the subject.

Mr. Barnes promised to exhibit at the next meeting, in conjunction with Mr. Holroyd, a series of specimens of calcareous tufa, and he asked Mr. Humphrey kindly to leave his specimens so that a comparison might be made.

Mr. Humphrey said he would be glad to do so, and would bring other specimens.

REPORT ON THE RECENT INTERNATIONAL GEOLOGICAL CONGRESS AT ST. PETERSBURG, WITH SKETCH OF THE GEOLOGY OF FINLAND.

By Mr. Mark Stirrup, F.G.S.

The seventh Session of the International Congress of Geologists met at St. Petersburg on August 28th, 1897, under Imperial patronage and with the sympathetic aid of the government and officials. The Congress was originally founded at Philadelphia, 1876, and its first meeting was held in Paris in 1878, and succeeding meetings have taken place at intervals of about three to four years, viz., at Bologna, Berlin, London (1888), Washington, and Zurich. The next Congress is arranged to take place at Paris in 1900, the great Exhibition year.

The principal objects of the Congress are the unification of the nomenclature of the various stratigraphical and chronological divisions of the earth's crust, and the establishment of an international system of colours to distinguish the various geological formations. The practical outcome of numerous deliberations of the Executive Council has been the commencement of a geological map of Europe, uniform in scale and colouring, part of which is now in the course of publication.

Other important questions of geological and international interest have not failed to be discussed, nor has the benefit of these international gatherings from a social and national point of view been overlooked. The St. Petersburg meeting eclipsed all former gatherings not only by its brilliancy and number of members, but by the vast scale upon which its

excursions were organised, extending from the western confines of Finland, across Europe to the Caucasus and the shores of the Caspian Sea, an extent of territory impossible of imitation by any other European nation. The excursions, which were mainly to districts of geological interest were under the direction of the best qualified leaders. Those excursions arranged to take place before the meeting, included Finland, the Baltic province of Esthonia and the mineral regions of the Ural Mountains, while the more distant portions of the Empire, as the Crimea, the Caucasus and the Baku Oil Wells were visited after the close of the Congress.

Six members of our own Society became members of the Congress although all these were not able from various causes, to attend the meeting. The opening meeting of the session at St. Petersburg was under the Presidency of the Grand Duke Constantine Constantinovitch, the Princess of Oldenburg, and the Minister of Agriculture and Domains, who successively addressed the members and gave them a hearty welcome.

The Czar and Czarina received a delegation in the Summer Palace of selected members representing the various nationalities attending the Congress; the members afterwards partook of luncheon.

The Grand Duke Constantine Constantinovitch and the Grand Duchess Elizabeth Mavrikievna invited a number of the geologists to an evening reception at the Marble Palace, where the great courtesy of the Grand Duchess and her linguistic accomplishments were the admiration of her guests. A banquet was given to all the members by the Mayor of St. Petersburg and the Municipal Council in the City Hall, where again a gracious welcome to the city was accorded. During the week of the meeting an invitation to the Czar's

Palace at Peterhof was issued, where a truly Imperial luncheon was served to a numerous company, the visitors being conveyed from the landing stage on the Neva, and from the railway station to the Palace in Court equipages. After the luncheon the park, the fountains, and the cottage of Peter the Great with its interesting mementos were visited. Amid all the distractions of a great capital, it is not to be wondered at, that the ordinary meetings for the reading of geological papers were but thinly attended.

The Geological and Mineralogical Museums of the Academy, the School of Mines, and the University were sought out by numerous enquirers, the collections being explained by the Professors and others in charge.

The famous skeleton of the Mammoth, obtained by Mr. Adams in 1803 on the banks of the Lena, with well preserved hide and hair and now in the possession of the Academy of Sciences, St. Petersburg, was the object of much attention. It is curious that among the numerous museums of the principal cities of Russia, nothing but fragments of the skeletons of this great beast are to be found therein, notwithstanding the many opportunities that Siberia has afforded, even in recent years, of valuable specimens.

M. Nossilov, the editor of the Russian Journal "Nouveau Temps" has recently drawn public attention to this deficiency of the museums of Russia, and he remarks on the good opportunity that now presents itself of securing a good example.

He says—"that while travelling in the Samoyeds country in May, 1897, he arrived at the mouth of the river Jouribei, and there learned that the natives had found, two years ago,

an entire Mammoth. The animal was enormous, and had slipped from a hill which had been undermined by the river. It had still remaining its flesh, wool, &c., when discovered; one of the natives had tried to remove the tusks, but had not succeeded." It is to be hoped for the sake of science that the Imperial Government will endeavour to obtain this and other specimens of the extinct pleistocene beasts which are found from time to time on the Siberian coasts

The week set apart for the meeting at St. Petersburg soon flitted by, in visits to palaces, museums, and to the numerous churches and monuments which adorn the city. One long day was devoted to a visit by the whole body of members to Finland's great natural curiosity of the falls or rapids of Imatra.

To accomplish this a special train was employed, which started from a distant station in St. Petersburg at 7 a.m., reaching Imatra *via* Viborg soon after mid-day, some refreshment meanwhile having been served in the train.

On our arrival at the Falls a grand banquet awaited us, served in a large tent erected specially for the occasion, in the grounds of the hotel close by.

The mighty mass of water which goes thundering by is composed of the waters of the Saima series of lakes, whose extent is said to cover an area of about 5,000 square miles. This huge volume of water on its way to Lake Ladoga has cut a deep gorge in the rocks down which the torrent speeds its way in magnificent turbulence, threatening destruction to any animated object that might chance to fall into its grasp. This gorge is narrow and straight, of some 350 or 360 yards in length, with an average width of about 25 yards. Within this distance of 350 yards there is a fall of

about 15 yards, causing the rapids whose roar is heard from afar, and whose imposing appearance claims the attention of the most indifferent. Upon the eastern bank of the gorge may be seen the old river bed of the Imatra, now abandoned and forest covered, strewn with rounded boulders and pebbles, and presenting numerous splendid examples of those smooth and rounded pot-holes or giant's kettles, often deep, so common in glaciated countries and which here seem to be the work of the ancient river.

After a full day and varied experience of the hospitality and musical abilities of the genial Finlanders we arrived back in St. Petersburg about 1 o'clock the following morning.

On Saturday, the 4th of September, 1897, the meeting at St. Petersburg terminated, the majority of the members going on to Moscow, where two or three days were to be spent before the departure of the various excursions to the Donetz coal-basin, the Crimea, Tiflis, and elsewhere.

The warmest thanks and praise are due to the Russian and Finnish geologists for their anxious and long continued labours in the preparation of the maps and the numerous guide-books that were distributed to the excursionists, as well as for the arrangements for the comfort of their visitors, some of whom were bound to the more distant parts of the empire and occupying a period extending to three months. Only those having a knowledge of the regions visited can fully appreciate the difficulties to be overcome—difficulties of transportation, the lack of suitable accommodation and food in districts sparsely inhabited, absence of good roads, and in localities where railway facilities were not available.

My part in the excursions was limited to a visit to Moscow and to the Finland trip, the latter, a country of extreme interest to the geologist and especially to the glacialist. Its appearance strikes you at once as that of a recently glaciated country, its smoothed and scratched rocks, its moraines and boulder strewn coast reveal its history. Notwithstanding the vicissitudes of a northern climate it is by no means a barren land nor void of characteristic beauties. Though boasting of no great mountain heights to allure the Alpine climber, yet its admixture of lake and woodland scenery has a quiet charm difficult to surpass, while its pure and unsullied atmosphere makes breathing a delight.

Mr. Stirrup went on to describe the geology of Finland, its crystalline rocks, its island girdled coast-line, its chains of lakes, which are but the shrunken relics of its ancient ones, whose memorials are the lacustrine deposits which rise in places to a considerable height above the plain.

Among some of the most remarkable features of the topography of Finland are the ösar, long sinuous lines or ridges of stratified sand and gravel, stretching across the country in some instances to more than 100 miles; they simulate the contours of artifical railway embankments, with sides sloping at an inclination of 15° to 20°. Many of the main roads run along the top of these curious accumulations.

They are supposed to be due to the deposit of sub-glacier streams during the retreat of the ancient glaciers. The erratic boulders of Finland's granite rocks were also referred to, as they have been traced half over Europe far to the south of Moscow, after a traverse of 700 to 800 miles from their place of origin.

Such like facts may give a faint idea of the climatal conditions of these northern countries during the "Great Ice Age."

On the motion of the CHAIRMAN, seconded by Mr. DICKINSON, the thanks of the meeting were given to Mr. Stirrup for his communication.

This concluded the business of the meeting.

Mr. Stirrup reports that since the meeting he has received an interesting souvenir of the Finland excursion, in the form of a printed copy of an Illuminated Address that has been recently sent through the Imperial Legation of Russia at Berne, and presented to Dr. J. J. Sederholm and Dr. W. Ramsay, Directors of the Geological Excursion, and to all the helpers and friends who assisted in its organisation. The Address is written in French (the official language of the Congress), and expresses in lively and appreciative language the intense gratitude of the visitors of all nationalities for their cordial reception and their admiration of the beauties of Finland.

It is signed on behalf of all the members who took part by Prof. Dr. J. A. Forel, of Morges, Suisse; and Prof. Albert Heim, of Zurich.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XVIII. VOL. XXV. SESSION 1897-98.

The ORDINARY MEETING of the Members was held on Tuesday, March 8th, 1898, at the Society's Rooms, Queen's Chambers, 5, John Dalton Street.

The President: Mr. JOHN RIDYARD, F.G.S., in the Chair.

NEW MEMBERS.

The following gentlemen were balloted for and unanimously elected Ordinary Members of the Society:—

Mr. ARCHIBALD DICKINSON, Bank Hall Colliery, Burnley.
Mr. RICHARD LANDLESS, Bank Hall Colliery, Burnley.
Mr. WIDDOWSON, Solicitor, 19, Brazennose Street, Manchester.

The PRESIDENT said the next business on the agenda was the discussion upon the paper read by Mr. G. C. Greenwell, at a former meeting on—

THE CORRELATION OF THE DOVER AND SOMERSETSHIRE COALFIELDS.

Mr. G. C. GREENWELL, Jun., said he had received a letter from his father, who was unfortunately unable to be present, and it might be convenient to read this first, and enter upon the discussion afterwards. The letter was as follows:—

"I send you, by parcel post, three sections, the object of which is to attempt to show the connection between the North of England coalfields. I am strongly of opinion that the Silkstone or black shale or clod coal of Yorkshire and Derbyshire is identical with the Arley mine of Lancashire; and I have also a strong opinion that the analogy extends to Durham (Hutton seam). The argument is strengthened by the analogy of the strata underlying the above in the various districts, to say nothing of the character of the coals.

"I do not attach much importance to the organic remains, from the absence of discovery where they at least may exist. There is an identity between an Anthracosia bed lying above and not far from the Low Main (Hutton seam) of Northumberland and its (as I suppose) analogue near Leeds; but there are fine displays of Megalicthys above this seam; also at Dukinfield in a higher, and at Denby in a much lower zone.

"As these sections indirectly elucidate some of my observations in my Dover paper, I should be glad if you would read this to the meeting and show them the sections. I am sorry that I cannot attend."

Mr. GREENWELL went on to say that having read the letter he hardly thought it necessary to make any further observations. He exhibited three sections: One of the North of England coalfield, which takes as its basis the Hutton seam; the second, of the Yorkshire coalfield, which takes as its basis the Silkstone seam; and the third, the Lancashire and Cheshire coalfield, which takes as its basis the Arley seam.

Mr. STIRRUP: I do not myself see what these sections have to do with the argument Mr. Greenwell brought before us in his paper. They seem to deal with quite another part of the English coalfield.

The PRESIDENT: Mr. Greenwell says, in his paper, that he does not place much reliance upon the vegetable remains found in the strata.

Mr. STIRRUP: But it has no relation with the North of England coalfield.

Mr. GREENWELL, Jun.: These sections are not so much to be taken as part of the discussion, but merely to elucidate, as he says, some of his arguments on the Dover coalfield—that is all.

Mr. JOSEPH DICKINSON: I may say, Mr. President, that I have looked at these sections, and those relating to Lancashire and Cheshire seem to be carefully arranged. I cannot speak as to all the details. The correlating of the Hutton seam with the Arley mine of Lancashire is opposed to preconceived notions. The whole of the Northumberland and Durham coalfield consists of only the Mountain mine or lower series of Lancashire, but in a highly developed form. A similar correlation took place by Mr. P. S. Reid some years ago. His paper appears in the Transactions of the North of England Institute of Mining Engineers; but it is a pure mistake to suppose that the Arley mine is in the Northumberland and Durham coalfield. There are no seams so high as the Arley mine there. The several coal seams, and the millstone grit, and the mountain limestone are shown in sections and described. The lower series of Lancashire has been extensively worked all round the coalfield.

Mr. HALL: There are two or three seams below the Hutton seam, in Durham, that have been worked—the Brockwell and the Harvey seams.

Mr. HARRISON: The most important seams immediately beneath the Hutton—although in some localities they subdivide themselves—are the Harvey, then the Busty, then the Brockwell.

Mr. BURROWS: I quite endorse what Mr. Harrison has said. I understood that the Brockwell seam was the lowest true coal seam in Durham.

Mr. GREENWELL, Jun.: I believe my father sent these sections, as I before said, to elucidate some of the arguments he used. He did not expect the subject to be discussed. It is a subject he has taken very great interest in, and worked very carefully at, and he thought perhaps the sections would show upon what he grounded some of his arguments.

Mr. GERRARD: I at first failed to see the connection between these sections and the paper on the correlation of the Dover and Somersetshire coalfields, but I find on reference to a Plate which accompanies his paper that Mr. Greenwell figures a section from Lancashire—the Ashton Moss section—and one of Shireoaks also, in connection with Somersetshire and Radstock, showing the interpolation of a series of red sandstones. They certainly have considerable interest, and if there be detailed information in these sections, I am sure it would be of advantage to all of us to have them published. If I might make a further suggestion, it would be that the discussion of the correlation of the seams in Northumberland and Durham, Yorkshire, Lancashire, and so on, is of such interest that it might be brought forward at another meeting, when these sections will have appeared in the Transactions. When I first looked at Mr. Greenwell's illustration of the interpolation of red sandstones, I did not clearly see the bearing of it. It appears to me he connects these red and purple sandstones, and so on, with the Pennant rock.

That is a very big jump. He endeavours to show, I take it, that the Dover coal seams—speaking from the boring sections only—are to be located below the Pennant rock. Then he connects the Pennant rock with similar red sandstones as at Ashton Moss and Shireoaks Collieries. There does, therefore, seem to be a connection between these sections and Mr. Greenwell's paper.

The PRESIDENT: Mr. Greenwell, in the letter which has been read to-day, asks that these sections may be returned to him. I presume, therefore, he has no idea of their being published.

Professor DAWKINS: I might suggest that one of the most interesting things we could do in this Society would be to have something in the nature of a Conference for the correlation of the east and west coalfields. I do not think we can really arrive at any satisfactory opinion from an isolated fragment here and there. I feel considerable difficulty in accepting the red colour of the sandstone as being of any particular value. With regard to the Coal Measure sandstones, anything which would lead one to suppose that the red sandstones of the Yoredales is identical with the Pennant rocks, in Somersetshire, appears to me likely to prove an *ignis fatuus*. I think it would be much better to arrange some date for a Conference to consider this question of correlation. I am sure that Mr. Greenwell would give us the benefit of his views and great experience, and there are numbers of gentlemen who are not here to-day who would come to a meeting of that sort, and whose opinion would be of the greatest service.

Mr. GREENWELL, Jun.: I would like to support the suggestion of Professor Dawkins. I am sure it would meet my father's views. I think his intention was that these

sections should be merely shown to-day; but I am quite certain if the question was really brought before the Society that he would either prepare a paper upon it, or, if unable to do so, would give me his views which I would place before the Society.

The PRESIDENT: In that case I think it would be well to defer the matter.

Professor DAWKINS: I think it had better be left in the hands of the Council to see whether a Conference cannot be arranged. I know as a matter of experience, that Conferences of that kind generally result in some important new light being thrown upon a subject. You get more light from individuals striking upon one another—and sometimes heat—than when an isolated individual comes here by himself and has no one to hammer at.

The PRESIDENT: Then we will proceed to the discussion of Mr. Greenwell's paper on the Correlation of the Dover and Somersetshire coalfields, and I shall be glad to hear the views of members. Perhaps Professor Dawkins, who has had much to do with the Kent coalfield, will open the debate.

Professor BOYD DAWKINS: I am not the senior member here who could say something on this question. I think my friend, Mr. Dickinson, from his experience and reputation, ought to open this discussion.

Mr. DICKINSON said: I have carefully read Mr. Greenwell's paper since it was printed, and it is quite evident that he must have taken considerable trouble in laying hold of all the facts which appear in it. He seems to rely chiefly upon the red and purple sandstones and marls in correlating the Somersetshire and other districts, including Lancashire and North Staffordshire, amongst which he gives the Ashton Moss section. I should like to say with regard to the

Ashton Moss section which he shows that it requires a very important correction. About half-way down the shafts a large fault, some 300 or 400 yards thick, is passed through, and the sinking has entirely missed that thickness of strata, including the Great Mine and the Roger. They were never seen in the sinking. Now the present Company have driven a tunnel to the other side of the fault, and have got the seams lying in their correct place, so that the thickness of the red rock shown in the sections has to be taken with certain corrections. Mr. Greenwell speaks of the Coal Commission which reported in 1871, and he seems to say that some of the principal arguments that were urged in favour of coal being found at Dover were based on the supposition (reasoning from east to west) that the coalfield in France, west of Valenciennes, approached nearer to the chalk than it did elsewhere. But he said a reasoning from west to east would not bear that out. I was one of the members of the Commission who signed that report, and I would like to say that that argument did not influence me in the slightest degree. What influenced me was the remarkable succession of coalfields which lie between the fiftieth and fifty-second parallels of north latitude. The The County Cork coalfield in Ireland; next the South Wales coalfield; the Forest of Dean coalfield, which is a perfectly isolated basin in itself; and the Bristol coalfield. Dover is in the same parallel. Then, eastward, on the Continent, the coalfields at Valenciennes, Mons, Charleroi, Liege, Aix-la-Chapelle, and Dortmund. Then Dresden, Waldenburg, and Kraku, all in the same parallel. It was the existence of this train of coalfields which made me think it likely that coal might exist under some of the overlying formations east of Somersetshire. Then Mr. Greenwell asked if the belief existed that coal was to be found at Dover. Why was the bore hole put down at

Battle? I think that that is explainable. I see Professor Dawkins is here; I believe he was the responsible adviser for the fixing of the site for the bore hole. I believe he put it there because he found that he could get into the lower formations with a much less depth of boring than if he had placed it elsewhere. But he is here and will be able to answer for himself. One other point I would like to mention, Mr. Greenwell in the paper mentions Mr. Brady's name over and over again as having originated the boring at Dover. I was surprised, after all the light that has been thrown upon the subject by Professor Boyd Dawkins, as appears from the Transactions of this Society, that not one of his communications should have been alluded to. I had always understood that the Professor was Sir Edward Watkin's geological adviser in this matter, and that he was the guiding spirit in the exploration.

The PRESIDENT: We can only deplore Mr. Greenwell's absence. I do not know whether his son can say anything further?

Mr. GREENWELL, Jun.: I think not.

Professor BOYD DAWKINS: I feel it difficult, Mr. Chairman, to discuss the paper on the Correlation of the Dover and Somerset coalfields, because the author has ignored the whole of my papers on the Dover coalfield in the British Association (Reports of 1887 and 1890), the Royal Institution in 1890, in the columns of *Nature* (6th March, 1890), and in the Transactions of this Society (Vols. XX., 1890, XXI., 1893, XXII., 1894), in which the successive stages in the discovery were recorded as the boring was carried on. He has further added to the difficulty by ignoring the last paper read before the Society in 1897 (Trans. Manch. Geol. Soc., Part VI., Vol. XXV.,) on the History of the Discovery of the South-Eastern coalfield, in which evidence was given as to

the share which Sir Edward Watkin, I and Mr. Brady had in the discovery, which had been claimed as the result of the solitary labours of the last. He also passes over in silence the discussion on the Kent coalfield at the Annual Conference of the Institute of Civil Engineers on the 27th May, 1897, when the matter was buried for good and all by Mr. Whitaker. I shall not waste your time and my own by repeating evidence already before you to prove that Mr. Greenwell is wrong in his account of the inception and the carrying out of the enterprise.

There are other points, however, which merit discussion without coming within touch of the personal equation. The statement (p. 378) that Godwin Austen and Prestwich founded the theory of the continuity of the coalfields of Somerset with those of France and Belgium upon no practical reasoned-out geological grounds, and that they argued from east to west, and not from west to east, is not consistent with the carefully reasoned-out conclusions and maps published by the former in 1859, and by both in the Report of the Coal Commission about ten years later. Nor can I agree with the author in the suggestion that the anticline north of the Netherfield boring, near Battle, is a continuation of that of the Mendips. It is, as I have pointed out before the Federated Institute of Mining Engineers, a continuation of the North Devon anticline, which runs eastwards through the vale of Wardour past Salisbury, and along the axis of the Weald from Petersfield to Dungeness. This is separated from the Pembroke-Mendip anticline by the great Mid-Somerset syncline, which passes eastwards through Tunbridge Wells and Tenterden to the sea to the south of Hythe. While, however, I differ from the author in the above matters, I entirely share his views with regard to the uselessness of the few fragments of ferns in fixing the exact horizon of the south-eastern coalfield. We do not yet

know enough of the range of the carboniferous ferns, through the Coal Measures, to use them for the identification of the strata. And I think that his suggested correlation of the field with the New Rock series of Somerset is valuable and likely to be true.

Mr. STIRRUP: I am glad that Professor Dawkins has already spoken, for he has taken up some of the ground which it was my intention to have touched upon—that is, with regard to the correlation of the new coalfields of Kent and those of Somersetshire, and their connection with the Franco-Belgian system. I scarcely think Mr. Greenwell can have felt all that his paper seems to express in its opening paragraph depreciatory of the labours of Prof. Prestwich and Mr. Godwin-Austen on the question of the Extension of the Franco-Belgian Coalfields into the south-east of England. There are few men in the geological world who have attained the eminence of Prof. Prestwich and Mr. Godwin-Austen, therefore it sounds rather severe to hear their arguments called unscientific. Mr. Godwin-Austen, in his report, certainly speaks of his views as speculative, but they had a most certain basis of geological fact, from which his conclusions were drawn. That paper was read in 1855 before the Geological Society of London. Since then much has taken place. Numerous small borings and sinkings have been made, and coalfields have been found to exist practically on the lines which Mr. Godwin-Austen laid down. Mr. Greenwell says: "The lines of argument varied—the idea of the first theorists appears to a very large extent (if not entirely) to be that because the Coal Measures in France were found to be approachably near the base of the Chalk, they would be found approximately near to it on the other side of the Straits of Dover, which was no scientific argument at all; the idea of the other scientists was based upon the great thickness of the upper formations

found in England, which had been shown to be superimposed upon the Coal Measures. The former idea was by the subsequent successful experiment at Dover proved in a sense to be right, but it was really no practical reasoned-out geological question at all; the argument, such as it was, was from East to West, but there was no well founded one from West to East." Now, Professor Dawkins has spoken on this point, and I quite support him, that there has been no more well-reasoned out argument than that of the extension of the French and Belgian coalfields into England, and on to the Mendips, than may be found in that memorable paper. (I might have read extracts in support of what I say) Mr. Godwin-Austen had also not overlooked the probable extension of these hidden Coal Measures into Somerset, which is directly in opposition to what Mr. Greenwell says; for instance, on page 62 of Mr. Godwin-Austen's paper the author remarks: "Applying this consideration to the structure of our area from Kent into Somerset, we may feel sure that a like arrangement of the older strata runs from the valley of the Thames into that of the Kennet; *along this line the Coal Measures may be reasonably supposed to have been preserved,*" a conclusion which was founded upon a line of argument which would be accepted to-day by the highest authorities. It is, in fact, the same line of argument which Mr. Greenwell would advise anyone to follow who asked him to survey a new coalfield of which he had no practical experience. It would just be, by a survey of the physical features of the area, noting the strike and dip of the rocks, their faults and fractures—it would be simply upon such like evidence that he himself would argue: "This is the best place to bore, on the chance of finding a coal deposit." Therefore, the argument, I take it, is one of the highest class, and which has been always so appreciated in the geological world.

Mr. Greenwell refers to his former papers on the Mendip area, in which he foreshadowed the near approach of the Coal Measures to the chalk, and says he proximately arrived at conclusions which have now been verified. Further, he says: "Having regard to the above, I think it may justly be concluded that the discovery of coal at Dover is due:—

"1. To the discoveries in Belgium and France, extended from exposed coal areas to those covered by upper formations, as in the North of England and elsewhere.

"2. To certain circumstances which occurred at Dover.

"3. To the consequent proposals to bore at the Tunnel Works by Mr. Brady.

"4. To their adoption by the Tunnel Company."

Well, numbers two and three I think are totally out of the reckoning. From what Professor Dawkins has said, and from what I have always understood, it was not at all from reasoning of that kind that this boring was entered upon at Dover. I should consider the primary reason for its being put down at Dover was the very fact that across the Channel, at Calais, a deep boring took place for water, and in the course of that boring they came across coal shales. That, I believe, was what gave the clue to the boring at Dover, because we know that the rocks occur much in the same relative position on the one side of the Channel as on the other. Then Mr. Greenwell introduces some question about the *Spirorbis carbonarius* and a specimen of *Prestwichia;* but what these have to do with the argument as to the correlation of the Dover and Somersetshire coalfields I have not been able to make out. As to the red and purple shales, that question having been dealt with by others, I do not propose to offer any observations. With regard to the value of the palæontological evidence I should differ somewhat from Professor Dawkins. In the Transactions of this

Society will be found a paper, by M. R. Zeiller, on the Fossil Plants of the Coal Field, translated and read by me before the Society, November 8th, 1892 (*Trans. Man. Geol. Soc., Part II., Vol. XXII.*), in which the whole of the palæontological evidence quoted by Mr. Greenwell will be found. Why Mr. Greenwell should have introduced this matter in support of his argument I do not quite see, because M. Zeiller himself remarks, with regard to the greater part of the Fossil Plants—I may say pretty nearly the whole—"these species indicate the Coal Measures, but the majority do not allow more precise information"; therefore he does not base any argument upon them. "Fortunately, however," he goes on to say, "it is not the same with *Neuropteris rarinervis* and *N. Scheuchzeri.*" "These, in fact, have been observed in America as well as in Europe only towards the top of the Middle Coal, or at the extreme bottom of the Upper Coal." With regard to the Radstock and Farrington beds, Mr. McMurtrie, the greatest authority we have on those beds in Somersetshire, quite agreed with the position that M. Zeiller with his palæobotanical evidence has assigned to them. M. Zeiller further says: "In England they appear to be common (that is the two species mentioned) in the Somersetshire basin, in the Radstock and Farrington beds, a little higher as it seems than in our fat coals of the Pas-de-Calais." The whole of the fossil plants from the Radstock, the Yorkshire, and our local coalfields have passed through the hands of Mr. Kidston—whose papers on the Lancashire Coal Plants I have read to this Society from time to time—and it is in reliance upon the personal investigations by Mr. Kidston of the plants derived from all these English beds that M. Zeiller has been led to take what I believe to be the correct view. M. Zeiller says: "One may then infer, by the presence of these two species in the Dover boring, that,

as Mr. Brady had presumed, the beds traversed by this boring belong to the upper region of the Middle Coal; and if one wished to put it more precisely, that they could not be more recent than the Radstock beds in Somerset, nor older than the deepest beds of the upper zone of the fat coals of the Pas-de-Calais." I support therefore the value of this palæontological evidence. We may not be able to pronounce definitely with regard to the greater part of the Fossil Plants—neither does M. Zeiller, for he says we find them ranging from the lower to the upper coal—but there are species which, so far, distinguish certain horizons or zones, and have never been found elsewhere. The question is are we to throw that evidence aside as worthless? Of course its value may be altered by subsequent discoveries. One or two of these special ferns may turn up in the lower beds, and then we shall have to modify our views with regard to them. But it seems to me we are rather ignoring the value of the evidence of fossils if we reject that evidence altogether. Similar evidence has been found of immense value in the coal explorations of France, in Germany, and in other European countries. It is relied upon as of great value in prospecting in new fields, and why we should be required to reject it here I am unable to understand.

Mr. C. E. de Rance wrote:—"I have read Mr. G. C. Greenwell's paper on the Correlation of the Dover and Somersetshire coalfields with much interest, and I have re-read his paper communicated to the Society in 1864, comparing the Belgian and East Somersetshire coalfields, and his subsequent paper, on *Prestwichia (Limulus) rotundata*, Prestwich, from Camerton Colliery in the latter coalfield associated with *Pecopteris Bucklandii* Brongniart, and encrusted with specimens of *Spirorbis carbonarius*, discovered by Mr. G. E. Feare, in the roof shale

of 'The Great Vein,' the uppermost workable seam of the highest (Radstock) series of the East Somerset coalfield. In the same volume of the Transactions is a very important paper, 'On the Upper Coal Measures of England and Scotland,' in which he describes (December, 1866) the occurrence of *Spirorbis* in Limestone or Libotwood, Uffington, Tasley, Baxterley, Longton, Manchester, *Whiston*, Rawbeck, Canobie Catrine, and other localities, extending over 300 miles, and he points out that these limestones are associated with curiously mottled marks suggestive of volcanic ash, and refers to these attaining their maximum thickness in the North Staffordshire coalfield. He states that Mr. Ward, F.G.S., of Longton, had identified two distinct horizons of *Spirorbis* in the latter coalfield, subsequent observations by myself, during my official examination of the seam, has increased this number to over twenty, proving that though a *Spirorbis* Limestone occurs in many coalfields at the Middle Coal Measures, as in Staffordshire and Warwickshire, they also occur in the former coalfield through 2,000 feet of Upper Coal Measures, and in Scotland in measures older than the carboniferous limestone.

"Mr. Binney quotes the Geological Survey Memoirs on the Warwickshire coalfield, which describes the *Spirorbis* Limestone as being there two to three feet thick, occurring about 50 feet below the Permian, which he estimates at 2,000 feet in thickness.

"In a paper read before the Society last year I endeavoured to show that the Zechstein Permian of the North of England is no where present south of a line drawn east and west, a little south of Stockport, and that the so-called 'Permians' of the Midland counties, overlying the uppermost members of the North Staffordshire, South Staffordshire, Warwickshire, and Worcestershire coalfields, is the equiva-

lent of the Ifton Rhyn coalfield of Denbighshire, and may be regarded as the nearest Upper Coal Measures, rather than the Rothliegende Permian, and lacking the absence of Permian rocks in all the borings touching the Palæozoic rocks of the South of England, including the Burford boring near Oxford, in which the Triassic rocks have almost wedged out, while south of Nottingham, and in Charnwood Forest, the Trias is represented by the Keuper marls alone. I cannot agree that the thin limestones are 'probably Coal Measures,' and were I not officially prevented from giving the results of my examination of the North Staffordshire fields, I think I could show that there is not the slightest likelihood of the highest Coal Measures being present in Kent, when a large portion of the series is found to be absent as far south as Warwickshire."

The PRESIDENT said no doubt Mr. Greenwell would take an opportunity of replying to some of the criticisms which had been uttered. Everyone would believe that Mr. Greenwell's sole object was to get at the truth, and a little criticism would help to elucidate matters.

NEW ASPECTS OF COAL-BED FORMATION,

Or, the Original Thickness of Coal Seams, with Suggested Explanation of their Non-Compressibility being due to supposed New Coal Plants.

By W. S. Gresley, F.G.S., F.G.S.A.

The paper in the absence of the writer was read by Mr. Stirrup.

It was an elaborate technical disquisition controverting text book views that compression by overlying strata had reduced the original bulk of coal seams to the present thickness of about one-fifth or one-eighth; which, quoting numerous geological and mining authorities, and referring to numerous sections of seams in various countries, and to unnamed coal plants, the writer considers (if not botanically) is certainly not supported by stratigraphical evidence.

Some remarks upon the paper were offered by Professor Boyd Dawkins, Mr. Holroyd, Mr. Barnes, Mr. Henry Hall, and other gentlemen.

The subject being one upon which various latitudinarian opinions are held, the Council consider it best to defer printing in detail.

Messrs. Barnes and Holroyd exhibited a series of British calcareous tufas; also a collection of British liassic ammonites.

Mr. Holroyd, referring to the specimens exhibited, said: I do not know that we have anything to say about these fossils except that they are here upon the table for examination by the members. With regard to the calcareous tufas a paper was read at our last meeting by Mr. Humphrey on some supposed calcareous tufas at Blackpool. Mr. Barnes has analysed the specimens which Mr. Humphrey exhibited and found them to be simply ordinary calcareous sandstone. It contains sand and other siliceous matters 66·4 per cent., and carbonate of lime 33·6 per cent. The usual run of calcareous tufas contain 99 per cent. of carbonate of lime; and in order that members may compare the specimens and make quite sure of what they are looking at we have brought to-day some very fine specimens of calcareous tufas from different parts of the country, and the comparison will show that the Blackpool specimens are not calcareous tufas but calcareous sandstones.

The President: Have you communicated with Mr. Humphrey?

Mr. Holroyd: Yes. There is another matter which I ought to mention. A letter has been sent to the Society from Mr. William Moister, of Blackpool, enclosing a mineral specimen. The specimen of selenite referred to is simply an ordinary specimen brought in the clay drift probably from some northern district—from the Oxford or Kimmeridge clay, where it is abundant.

The PRESIDENT moved a vote of thanks to Messrs. Barnes and Holroyd.

Professor DAWKINS said he had much pleasure in seconding it. The collection of fossils brought by Messrs Barnes and Holroyd was a most magnificent one.

The motion was passed, and the meeting separated.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XIX. VOL. XXV. SESSION 1897-98.

The ORDINARY MEETING of the Members was held on Tuesday, April 12th, 1898, at the Society's Rooms, Queen's Chambers, 5, John Dalton Street, Manchester.

Mr. JOSEPH DICKINSON, F.G.S.,
(in the absence of the President) in the Chair.

NEW MEMBER.

The undermentioned gentleman was balloted for and unanimously elected an Ordinary Member of the Society:—

Mr. ALFRED NAYLOR, Cotes Park Colliery, Alfreton, Derbyshire.

ON THE ROCK SALT DEPOSITS OF NORTHWICH, CHESHIRE, AND THE RESULT OF THEIR EXPLOITATION.

By Mr. Thomas Ward, J.P., F.G.S.

PART II.

In the first part of this paper, read on June 15th, 1897, the upper bed of rock salt was chiefly dealt with. The second bed, in which all mines for over a century have been sunk and worked, is not so clearly defined. It is known, however, to underlie not only the whole of the upper bed, but a further considerable area in all directions. On the Plan printed with Part I., showing the upper bed, and the position of the various boreholes put down outside the area of this bed, we can mark the points where no salt has been proved, and thus fix the limit of the bottom bed at these points.

The Hewitt and Renshaw borehole was put down 354 feet, or about 290 feet below Ordnance Datum, and no salt was proved. This borehole was very little more than a mile to the south-east of the coal boring at Marston. To the west there are three shafts and borings put down by Messrs. Brunner, Mond & Co. The shaft along the canal in Anderton, and about one and a quarter miles from the coal borehole, nearly due west, was just outside the bed of salt. Rather more than a quarter of a mile further to the west a boring was put down in Gunner's Clough, Barnton, to the depth of 364 feet, or 268 feet below Ordnance Datum, and no traces of salt found, although this was considerably below the level of the lower rock salt. Another borehole was put

down about half a mile to the south of this, and to the W.S.W. of the coal borehole, and rather more than one and a half miles from it. This borehole in the Poultry Yard, Winnington, was put down a depth of 332 feet, or 278 feet below Ordnance Datum, and no traces of either rock salt or brine were met with, and, what is curious, and quite unexpected, there was no fresh water found. The distance from Hewitt and Renshaw's borehole to the Poultry Yard borehole is two and a half miles direct east and west. Few other boreholes have been put down to a depth sufficient to have proved the non-existence of the lower bed of salt. Pimlott's borehole in Leftwich, one and a half miles to the south-west of the Marston borehole for coal, was carried to a depth of 334 feet, or fully 290 feet below Ordnance Datum, and although brine was found, there was no certain trace of rock salt of any thickness. From 243 feet 6 inches to 301 feet 6 inches the borings showed red and grey marl mixed with rock salt, and from this point to 334 feet, red marl. The average depth of the top of the bottom bed of salt is 160 feet below Ordnance Datum; the average thickness of the bed 88 feet; and the average depth of the bottom of the bed 248 feet below Ordnance Datum. The surface at Pimlott's borehole is 43 feet above Ordnance Datum, the bottom bed of rock salt therefore ought to have been met with somewhere between 203 feet and 291 feet from the surface; or, if we take the most extreme points shown in the district, it might have been met with anywhere between 184 feet and 306 feet from the surface. According to the following section, there was not the slightest trace of salt down to 243 feet 6 inches; and in the next 58 feet we only meet with traces of rock salt accompanied by the usual marls. It is very evident that had the rock salt been there in any thickness, it would have shown itself, and been noted as a distinct body separate from the red and grey marls.

Section of Borehole put down in Pimlott's Boiler Yard, Leftwich.

Depth from Surface. Ft.	in.		Thickness of Strata. Ft.	in.
2	0	Surface soil..	2	0
11	0	Boulder clay	9	0
76	0	Quick sand..	65	0
81	0	Clay	5	0
203	6	Quick sand with thin beds of marl ..	122	6
243	6	Strong red marl	40	0
301	6	Red and grey marl mixed with rock salt	58	0
334	0	Red marl	32	6

It was not till a depth of 255 feet was reached that any trace of salt was met with, and this was in the form of a very weak brine; and it was not till 301 feet 6 inches was reached that a strong brine was found. The only conclusion that can be come to is, that both beds of rock salt are practically non-existent at this spot. This being so, the Riversdale boring, nearly half a mile further direct south, and entirely away from the great mass of rock salt, forms a problem difficult to solve. The boring showed two thin beds of rock salt, the first being 10 feet thick, and described as amber rock salt and marl; the second bed, 12 feet thick, is called white rock salt. Between these two beds we have 54 feet of marls and gravel. Both of these beds lie between the points at which the bottom bed of salt might be expected to be met with, if connected with the rock salt of the Northwich district. Taking the average of the district, we might expect to meet the lower bed anywhere between 215 and 303 feet from the surface; or between the extreme points 191 feet and 313 feet. The first bed of 10 feet of salt and marl was met with at from 225 to 235 feet from the surface; the second bed of 12 feet was found from 289

to 301 feet from the surface. From the first appearance of the salt to the last, when red marl appeared again, there were 76 feet of salt, marls, and gravel. These all fall within that portion of the borehole where the lower bed of salt should be met with; but as the following sections will show there are strange anomalies.

SECTION I.

				Feet.
From 225	to 235	feet	Amber rock salt and marl.. ..	10
,, 235	,, 238	,,	Very soft marl	3
,, 238	,, 240	,,	Gravel..	2
,, 240	,, 286	,,	Red and blue marl..	46
,, 286	,, 289	,,	Honey-combed marl	3
,, 289	,, 301	,,	White rock salt	12
,, 301	,, 303	,,	Fine red marl	2

SECTION II.

,, 235	,, 245	,,	Salt rock and marl	10
,, 245	,, 285	,,	Red and grey marl with hard bands	40
,, 285	,, 286	,,	Flagstone	1
,, 286	,, 302	,,	Brine and rock salt	16

The two boreholes were put down by different parties, but were within 21 feet of each other. In both cases we find between the two beds of salt,—marls,—and in Section I. two feet of gravel. This gravel consisted of water-worn stones about the size of peas and beans. I have not met with anything similar to this in any other Section of the many that have come before me. It is well known that the beds of rock salt are, in places, very much mixed with marl: but supposing the two beds of salt in this boring to be really portions of the lower bed common to the district, such an occurrence as from 40 to 50 feet of marls without any trace of salt intervening between such portions is most extraordinary. Again, if, as all the nearest boreholes show,

the lower bed of salt was thinning out rapidly half-a-mile away there could scarcely be some 76 feet of it left at Riversdale.

In Pimlott's boring, it was evident that the lower bed of rock salt was practically non-existent, although the borehole was about half-a-mile nearer the salt mass. In the borehole put down in the triangular piece of land between the railway lines on the Witton House Estate, about three-quarters of a mile nearer the main mass of salt than Riversdale, the first, or upper salt, was missing, and the lower bed was only 60 feet thick, whilst at Neumann's Witton mine, about 500 yards away and nearer to the main mass, it was 80 feet thick; and in Penny's Lane mine, less than 100 yards further away, it was 90 feet thick. It seems very improbable that the lower bed, which shows a decreasing thickness in all the boreholes put through it, as the distance from the Marston borehole increased, should at Riversdale have suddenly become thicker.

Taking the Marston borehole as a centre and proceeding west, at the distance of 1½ miles the lower bed of salt has disappeared. To the south-west, at the distance of a mile, at Baron's Quay, the bed retains its thickness of 91 feet, but at 1½ miles—Pimlott's borehole—it has either disappeared, or there are only faint traces in the marl for 58 feet. Due south, we have at the Cheshire Amalgamated Brine Shaft—three-quarters of a mile away—a thickness of 84 feet, at Neumann's Witton mine, one mile away, 80·6 feet; and at the Diamond borehole, on the Witton House Estate, 1¼ miles away, 60·25 feet. A little to the east of south we have the Manor Farm borehole, three-quarters of a mile away, 83 feet; and Bowman, Thompson and Co.'s boreholes, one mile away, 73 feet, and rapidly thinning off. A little further to the north, and E.S.E. of the Marston borehole, at Hewitt and Renshaw's borehole—about one mile away—the rock salt

has entirely disappeared. No boreholes or mines have been put down on the E.N.E. district, but on the north and north-west there are several mines. In the furthest of these—Marston Hall—half-a-mile away to the N.W., the lower bed is 86·6 feet. The only conclusion to be drawn from all the evidence to be obtained, is that at about 1½ miles from the Marston coal borehole the lower bed practically dies out. If so, what about Riversdale? Without further knowledge this question must be left unanswered.

As far as proved, the area of the salt beds in the Northwich district is about four square miles. There is a little uncertainty as to the northward extension; but as the quantity of marl mixed with the salt increases towards the north, there is every probability that the beds soon die out in that direction.

I have made a careful calculation, based upon the shipments made by the Weaver, by canal and by rail and road, of the salt sent out from the Northwich district during the last two centuries. The quantity before that time was very small, and may be neglected. The quantity of white salt manufactured from brine will approach to, but probably not exceed 25,000,000 of tons. The quantity of rock salt may be safely put down as 10,000,000 tons. Thus from the salt stock of the Northwich district some 35,000,000 of tons of salt have been abstracted.

If we take the area underlain by the salt beds at four square miles at the utmost, and the average thickness of each salt bed at 27 yards, which is about correct as far as we have proof; we have 2,560 acres of salt beds 54 yards thick, or $2560 \times 4840 \times 54 = 669{,}081{,}600$ cubic yards. The average weight of a cubic yard of rock salt being 32 cwts., there were originally 1,070,530,560 tons of rock salt in the Northwich district. If we call this one thousand millions of tons, and allow 25 per cent. for the marl contained, we cannot estimate the original quantity of salt in

the deposits as less than 750,000,000 tons. Again, if to the quantity of white salt made we add at least 25 per cent. for wastage of various kinds, we may safely say that over 40,000,000 of tons of salt have been taken from the mass forming the Northwich rock salt deposit. It is with the results that have followed the taking away of this enormous bulk of salt from so limited an area, that the remainder of this paper will specially deal.

In the year 1887 I read a paper before this Society entitled "On the Subsidences in the Salt Districts of Cheshire, their History and Cause." In this paper I dealt very fully with the subsidences caused by the pumping of brine for the manufacture of salt, and I also touched upon the subsidences resulting from the mining of salt, so that it will only be necessary to shortly recapitulate what was said, and then to deal more fully with the recent extensive subsidences.

The results of the exploitation of the beds of rock salt may be summed up under the following heads:—

(1.) Subsidences caused solely by brine pumping.

(2.) Subsidences resulting from mining.

(3.) Subsidences resulting from a combination of mining and brine pumping.

I have frequently explained that fresh water is the greatest destroyer of rock salt, and the worst enemy the rock salt miner has to encounter. Salt is one of the most soluble minerals, and fresh water will take up about one-third of its own weight of salt before it becomes a saturated brine—three parts water, one part salt. The constant removal of the brine, for the purpose of abstracting the salt it contains by means of evaporation, and its constant replacing by fresh water, which quickly saturates itself on the surface of the salt, lead to the gradual lowering of the salt bed, and the sinking of all the overlying earths. It is

this kind of sinking which so seriously affects the town of Northwich and works such havoc with the houses and other property. If the water attacked equally the whole area of the salt the land would sink equally, and, beyond the general lowering of the level, little or no damage would be done. This, however, is not the case. Each pumping centre sets up a flow towards itself which follows the line of least resistance. The water following this defined course rapidly eats itself a channel, which widens and deepens, and the overlying earths follow this channel, and repeat on the surface amongst the houses and other property the channel made below. Any one visiting Northwich and passing through Witton Street and High Street, also along the lower portions of Castle Winnington and Leftwich, as well as along Warrington Road, may easily see the hollows in the road and the cracked and sinking houses on either side. When these sinkings occur in fields they may be recognised by pits and hollows in which the water remains instead of draining away. For further information as to these subsidences see the paper before referred to.

The subsidences caused by mining I have referred to in the former part of this paper, more particularly those relating to the mines in the upper bed of salt. Very few of the subsidences resulted from bad mining. It is quite possible that in a few instances the pillars were insufficient in numbers or strength; but as far as regards the mines in the first bed of salt the agent of their destruction was water, and the shafts in nearly every case the means by which the water reached the salt. Nearly the whole of the large lakes formed or forming in and near Northwich, as well as the conical "rock pit holes," locally so-called, are in the area of the mines in the upper bed of rock salt, though the water surface covers a much larger area than the old mines themselves covered. This is caused by the low ground alongside

the brooks and river—near which the mines were sunk—gradually subsiding owing to the pumping of brine, which caused the surface to sink below the water level, and so to become permanently flooded. The large lake, known by the name of "The Top of the Brook," and the flashes alongside the Weaver (now nearly filled up by waste from the chemical works of Brunner, Mond & Co.) cover a number of the old top mines, but there are no bottom mines under this area.

Up to the year 1800 there had been shipped down the Weaver about 2,000,000 tons of rock salt; more accurately perhaps 1,900,000 tons. The lower bed of rock salt was not discovered till 1781; but after that date all new mines were sunk to the second bed, and by 1808, when Holland's "Agriculture of Cheshire" was published, there were some ten or twelve mines working, all of which were in the lower rock salt. If, then, we consider all the rock salt shipped up to 1800, as from the top mines, we shall make sufficient allowance for any shipped after, up to 1808, by setting it off against that obtained from the bottom mines prior to 1800. As already mentioned, the top mines were worked to a depth of eleven or twelve yards. The pillars were pretty numerous; but if we consider the depth as ten yards, it will allow for the pillars and give pretty nearly the area of the mine. At ten yards deep there would be 48,400 cubic yards of salt to the acre, or roughly about 77,000 tons. It would seem then that the area of the top mines was about twenty-six acres. Some years ago (before I had obtained the evidence I now have) I concluded that the top mines could not have been more than forty acres. It would be safer now to estimate them as not covering more than thirty acres. If we reduce the working height, and increase the number of pillars, so as to make the utmost reasonable allowance, forty acres would be more than ample. The area of the Top of the Brook

has been, at one time, close upon 100 acres. Out of the forty old top mines marked on the map given in the former part of this paper, only thirteen can be said to be certainly under the area covered by the 100 acres of water. It will be at once evident that the old top mines are not answerable for more than a small portion of the subsided area forming the Top of the Brook. Of the remaining old mines, some fifteen can be traced by the existence of rock pit holes; six have been filled up; one is now in existence; and the others have been covered by water within a comparatively recent period. The Dunkirk, Marston, and Marbury districts are noted for their rock pit holes, which form a distinguishing feature on the 25-inch Ordnance Map.

When the lower bed of rock salt was discovered, it was found that the upper portion of it was similar in its composition to the upper bed, and contained a considerable quantity of marl. Lower down, near the bottom of the bed, for about five yards, the rock salt was found to contain less marl, and the mines were all worked in this section of the salt. Although this purer portion of the salt is common to the whole area of the lower bed, and indicates a period of less rainfall when it was being deposited, it is by no means of equal purity throughout; nor is it so pure as the rock salt in most of the German and American mines. The marls being tinged with iron, give a reddish brown appearance to the salt when present in even the smallest quantities. The German and American marls, in most cases being of a greyish or dirty white colour, do not show so conspicuously in the salt; so that, given two samples of salt, the one English, the other German or American—each containing the same percentage of marl—the English salt would appear to be the most impure.

The absence of any very distinct stratification in the salt, and the extraordinary manner in which the marl and salt

are mixed up, make it rather difficult to clearly comprehend the state of affairs when the salt was being deposited. In my paper on rock salt, read before this Society on January 26th, 1886, I entered very fully into the way in which salt is now being formed in all parts of the world; and the more I examine the Cheshire rock salt beds, the more convinced I am that the description there given is the only one that will account for the curious conglomerate or mixture of salt and marl that we call rock salt. Now and again we find running through the mass for a short distance, and turning about in all sorts of ways a thin seam of pure marl; then again, we meet with small portions of pure rock salt surrounded by a mixture of marls and salt. In discussing the peculiarities met with, we have to bear in mind that, in working the rock salt, we are not uncovering and removing it in the order in which it was deposited; but are exposing a section cut vertically through the mass, and therefore showing the deposits of many seasons. If, therefore, there were any very clearly defined lines of stratification they would be apparent. We may, if we so wish, consider the portion of the mass that is freer from marl as indicative of stratification.

This light-coloured band, as before mentioned, is common to the lower bed of rock salt, and is generally accompanied by a thin band of nearly all marl immediately overlying it, and by seams of marl and salt varying very much in thickness, but pretty regular in direction. There are other indications seeming to show signs of stratification, but they are so irregular that we are bound to conclude that the circumstances under which they were formed were very changeable. The most common appearance of the salt is that of a reddish brown mass, consisting of varying proportions of marl and salt. Just overlying the portion of purer salt, there is a mass of striated rock salt, varying from a few inches to two or three feet in thickness. The rock salt is

striped almost like a zebra—the dark stripes being where the marl most predominates. These stripes are only an inch or so in thickness, the intermediate salt being very fairly free from marl. The marl does not appear as pure marl; but only as a tinge in the salt. In this portion of the salt, we have what seems to indicate "pot holes." There would appear to have been depressions of various shapes and sizes at the bottom of the salt lake, and it would seem as if during the salt depositing season, layers of pure salt were formed all over the bottom of these depressions. Such depressions are common in the shallow portions of existing salt lakes, and as the dry season causes the lake to diminish they are left behind as shallow pools on the margin of the lake. When the wet season again comes on, and the lake begins to extend, these depressions are again filled, and the marl settles more freely in the hollows than elsewhere. This is clearly seen in the section of the rock salt now being described. I give a section recently copied by me. It will be seen that the dark coloured mass in which the marl largely predominates lies as it were in cups or "pot holes." The section is about six feet deep, and is in the heart of the rock salt, just above the portion of the salt that is most pure in the lower bed. To get the whole five yards or less of the best salt it is necessary to uncover it so as to blast it more easily. For this purpose a gallery of about six feet in height is made. The making of this gallery is called "roofing," and the rock salt thus obtained is known as "roof" rock, and is much more impure than the portion below it. The making of this gallery is the most costly part of the mining. It was originally done by the pick and small blasts off the face of the rock. Now in most mines a coal cutting machine is used and the blasting made easier. The process of roofing so as to uncover the good salt below is called "making" work, the blasting of the rock uncovered

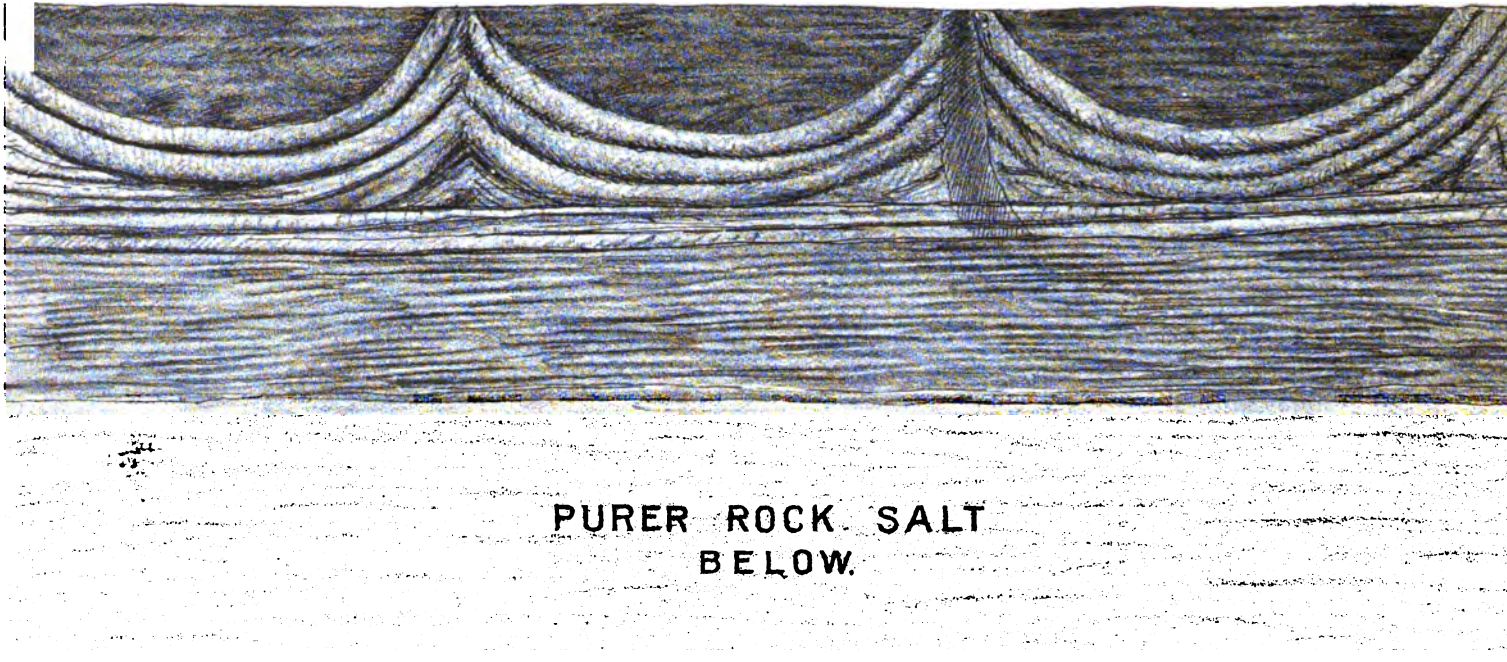
is called "getting" the salt. It will be evident that as only a sufficient height for a man to work in is roofed we cannot be sure that any section exposed in the roofing tells a complete story.

The section, which rather exaggerates the contrast in the colours of the rock salt, gives a fair idea of the appearance of the salt in this particular portion of the lower bed. Without attempting to explain clearly this peculiarity, there seems no doubt but that the bottom of the old salt lake was irregular, and that these masses of dark coloured salt, which give so much trouble to the miner, and are so commercially useless, are the result of the muddy flood waters being confined to some extent by the pothole.

The purer rock salt, known as the Lench, is very easily blasted. It is worked down in rough steps, and three blasts are sufficient to reach the sole of the mine. The salt is worked out in drifts, each usually extending from pillar to pillar, that is 25 yards. Each pillar is usually ten yards square, giving a supporting area of 100 square yards; occasionally they are left twelve or more yards square, and a few are even larger still. When the mines in the bottom rock salt were first worked the pillars were left five yards square, giving a supporting area of only 25 yards. In the mines in the top rock salt, as before explained, the pillars were even smaller than this. There can be no doubt but that time has shown that the five yards' pillar was too small. This must have been discovered in the first half century of the working of these mines, as after that period the pillars began to be left larger. A lease, dated 1852, will show what was then considered the proper and usual size of pillars, and also the customary height of working. Under the head of "Height of Excavation, Pillars, &c.," we read "The excavation to be not more than 15 feet, nor less than 13 feet, measured from *sole* to *roof* of mine. Pillars of eight yards

Trans. Man. Geo. Soc. Part XIX. Vol XIV.
To illustrate Mr. Thomas Ward's paper.

ROUGH SKETCH OF SECTION SHOWING APPARENT STRATIFICATION.



square at distances of not more than every 25 yards." At the celebrated De Tabley sale in 1828, a large portion of the land in Witton (Northwich) containing rock salt was sold, and then the condition for pillaring a mine was "leaving pillars five yards square at every 20 yards distance." Directly after this time, it was found that the pillars were too weak and that the roof was beginning to crack. I possess copies of probably the earliest report made on this state of affairs, and as the report refers to two mines now completely under water, and casually refers to two others flooded, but not yet under water, it may be interesting to put them on record, the more so as Samuel Fowls' report was made by the most competent man of his time, and gives a very clear and accurate description, which will apply to what has been going on since his day, and which I will describe shortly.

The Report is entitled "Survey of the Rock Pit, whereof a part is belonging to John Blackburne, Esq., & Co., in Wincham. June 14th, 1830."

"In consequence of some appearance of failure in the Pit becoming manifest to the workmen, very particularly on Friday, the 3rd day of June instant, when noises were heard that alarmed them for their own safety. I was requested by Thomas Fowls, your agent at Northwich, to go down and examine into the state of the said pit, and give my opinion as to the danger to be apprehended, and if possible to point out and advise measures for the safety of the same. On Saturday last I went down and found things in a very alarming state, for besides a number of cracks in the roof or ceiling of the pit, one extending perhaps 100 yards in length, another near fifty yards, from a quarter of an inch to an inch wide, with others in transverse directions, there are pieces burst off several of the pillars; some are now hanging almost loose in different shapes and sizes from the weight of

(shells of) a few pounds to some tons; likewise cracks down other parts of the same. Furthermore, the safety of several pillars is much endangered, if not absolutely injured, by water from the shaft, which appears for a great length of time, if not from the first forming or sinking of the pit, to have been conveyed into a hole sunk into the sole or floor of the pit for the convenience of being drawn up at regular periods in tubs by the horses, and latterly by the steam engine. This water has melted some of the stratas under the flooring, and now has passages under to great distances, indeed, no one can say how far they go or where they terminate.

"Moreover, the pillars are of little dimensions and very few in number, more especially in the part now in the occupation of C. W. Newman & Co. From the circumstances before stated, I consider the pit in a very critical and dangerous state—that the time of its failure is not very distant (nor can any one say how soon), and to use any artificial means with any probability of success for the support and durability of the pit, they must be set about quickly and on a large scale, not only in the part belonging to John Blackburne & Co., but in the whole pit, likewise in the pits belonging to E. V. Townshend, Esq., with which they are connected, consequently the failure of one is certain destruction to the whole, and reports state that his pits are not in a much better state than the pits I have been examining.

"SAMUEL FOWLS.

"Northwich, June 14th, 1830."

(I omit all Fowls' suggestions as to dealing with the water, and making artificial pillars to support the roof, &c.)

Fowls' report was looked upon as an alarmist one, and immediately on its receipt two other parties about whom I know nothing, but think they were most probably mine

foremen, were asked to make a report. This report is also very instructive, as showing that up to this date there appears to have been no idea of the roof "creeping."

The report is entitled, "Survey of John Johnson and William Cross as to Rock Pits at Witton Brow, 19th June, 1830."

"Marston, 19th June, 1830.

"We, the undersigned, having been requested to go into the rock pits of the following rock salt proprietors, viz., John Blackburne, Esq., & Co.; Messrs. Newman & Co.; R. P. Hadfield & Co.; and Messrs. Charles Broady & Co., in order to ascertain if any danger were likely to accrue to the workmen in any of the before mentioned pits in consequence of any of them being in an insecure state.

"Upon a minute examination of the said pits we find several cracks or fissures in each, which we believe to be of very inconsiderable depth. We cannot positively state from what cause they proceed; but it is our opinion that they are produced either by the atmostpheric (sic) air or by the blast of powder. We are decidedly of opinion that the said cracks do not proceed from any weight on the roof of the rock. We consider each pit to be entirely free from any danger, and we should not hesitate to work in any of them.

"As witness our hands,

"JOHN JOHNSON.
"WILLIAM CROSS."

I have given these reports as bearing on the first beginning of the destruction of mines in the bottom rock salt, and as tending to prove that the causes now operating are similar in all respects to those first observed.

Fowls was right on every point. The small pillars and their fewness caused the creeping and cracking of the roof

and the splitting of the pillars; and the water dripping down the shaft and running under the sole of the mine found its way under the pillars and ate away the salt as has been the case since. Fowls' prediction as to the dangerous state of the mines was fulfilled to the letter; by 1833 the roof had fallen in and buried one of the miners, and the water had got in and flooded the mines. From this time onwards mine after mine collapsed and became flooded and filled with brine. I have a note of a bottom mine which was flooded in 1825. This mine is now full of brine, and several cottages are above it. The brine has not been pumped or disturbed and the pit is not connected with the neighbouring flooded mines, consequently the surface over it has not been destroyed and covered with water. There is an old rock pit hole where the shafts were. I call particular attention to this to show, that unless the water or brine is pumped out and fresh water takes its place, and saturates itself on the surrounding rock salt, and is in its turn pumped out, all danger of subsidence is past after the first influx of water has become saturated brine.

I think it may be desirable to go into the matter a little more fully, and to leave a record for future reference and information, by giving a shortened form of a report made by me of the Old British Mine, which is now flooded, and which collapsed in a similar manner to Blackburne's pit.

At the end of 1887, I inspected the Old British Mine for the purpose of advising about the removal of the brine pumping apparatus from the mine and the sinking of another shaft, out of which the old mines full of brine could be tapped. The common reason given for the desired removal was that the sole of the mine was rising and pushing up, and damaging the pumps and engine, and it was feared the mine would soon be destroyed. It was not

the sole of the mine that was rising, though appearances seemed to justify this idea. It was known the roof was creeping, but not suspected at that spot so particularly. I had visited the mine twice previous to this inspection.

"The pillars of the mine had been left too few in number and too small in size, the result being that the roof many years ago began to "creep" in the weakest portion near the shafts. The first signs of "creep" were seen in the pillars, which began to break or split at the angles. As the sinking went on, the splitting and shivering off of the pillars continued, and in the spaces between the pillars the roof cracked, the cracks radiating from the shafts. At the lowest portion of the sinking roof the cracks also radiated, the bulging portion of the roof being badly cracked, some of the fissures being fully a foot wide and extending upwards as far as the light from a lamp would penetrate. In one place a huge mass of the roof had slipped, and was fully nine inches lower than the surrounding portions. The pillars near the old shafts and along the line of weakness were all crushed to pieces, and resembled a heap of broken salt and *debris* of a conical shape. The roof "creeps" at the rate of half an inch a month; but where the portion of roof had slipped, the sinking has been more rapid, especially during the last few months. It is pretty certain that ere long the roof will fall. Taking the normal height of the roof as fifteen feet from the sole, it is now five feet ten inches in one portion, and from eight to nine feet over a considerable area. Beneath the old shafts the water that had fallen down them had crept under the sole by dissolving the salt, and, having become saturated brine, proceeded to form salt crystals, the air of the mine being very dry. These crystals, in their growth, had heaved up or lifted the floor or sole of the mine, splitting and breaking it up as if it had been blasted. The roof sinks from the side walls of

the mine towards the shafts in all directions. The enormous pressure that the pillars had to support may be judged from the fact that a tunnel cut for a distance into the heart of the rock salt was being gradually compressed, and the door posts of a door to close the tunnel broken across and bent out of form."

This sinking went on till water made its appearance in the mine through the cracks in the roof, and then the brine pipes which had conveyed brine from the flooded mines across this mine to the pumping stations were removed, leaving the mine to fill with brine rather than with fresh water. As the British mine was one of very large size, it drew off from the neighbouring inundated mines,—in becoming filled,—an enormous quantity of their contents. This was followed immediate by the collapse of the shafts of Blackburne's new mine, which was in immediate proximity to Blackburne's and Neumann and Ellson's mines, and which were now covered by a deep lake of fresh water. An attempt was made with some success to choke the large opening into the bottom mines, thus made, before the land sunk low enough to let in the lake of fresh water, which was only separated by a low bank a few feet in width. This took place in 1891. Since then the bank has sunk, and the large hole caused by the sinking of the shafts has filled with water, and has become part of the Neumann's or Marston flash or lake.

After the collapse of Ashton's mine in 1838, it was not long before the whole of the Dunkirk mines that had been worked out, viz., Ashton's, Tomkinson's, Naylor's, Marshall's, Wakefield's, Worthington's, and Barton's old mine filled with water. This was about 1840. At this time there were seven flooded bottom mines in the Marston and Wincham district, eight in the Dunkirk district, and two in Witton, near the Weaver. Many of these, especially in

the Dunkirk district, had over them what are locally called rock pit holes, or small lakes, where the shafts had collapsed. Once filled, and the water become saturated with brine, no further movements of the surface took place, except such as were caused by the pumping of brine formed on the top bed of rock salt, as before explained.

I have referred now to two results of working the rock salt, viz., a gradual lowering of the surface by the pumping of brine, and the collapsing of mines, leaving small lakes or rock pit holes on the surface. Of course the mining of the salt leaves large cavities below.

When a mine has once filled with water, and the water has become saturated brine, no change will take place for an indefinite period. There are mines which are isolated from the general body, and which have been filled with brine for over half-a-century, without any change on the surface being perceptible, other than such as has been caused by the pumping of brine from the rock head. One of these was filled in 1825, and there are inhabited cottages over it, which have been there since the mine was working. Another has a set of works over it, and barring the disturbance caused by brine pumping from the rock head, no ill results are perceptible. About 1850 and afterwards, the supply of rock head brine began to fail, and attention was turned to the enormous reservoirs of brine contained in the old mines. A few of these old mines had been worked into one another so that when one became flooded the others followed. As the water that had flooded them had come in over the surface of the top rock salt and down the shafts they had been a long time in filling, and had drained off a good deal of the ordinary rock head brine. The first attempts to pump brine out of the bottom pits were successful, and for a time a good supply was obtained. By degrees however the pits in the

Dunkirk district became pumped down. Connections were made with neighbouring pits full of brine, and the same result after some years followed. About 1870 Captain Townshend commenced to pump out of his flooded mines, which were connected with the Marston group. He had not pumped long before the results were seen on the surface. As the mines were pumped down the Blackburne's and Neumann's and Ellson's, which had collapsed many years before gave way, and the top mines also collapsing let the water of a small brook which crossed over the surface into the mines below. From the moment this took place there was a rapid subsidence of the land overlying the mines, and a lake was formed, which is of very great depth. At intervals, as the mines below get exhausted, or partially so, the water of the lake breaks in and replenishes the brine supply. Every inrush of water eats away the salt, and the subsidence goes rapidly on. In the Dunkirk district (the bottom mines of which are not connected with the Marston district) the mines were pumped very low in 1880, and on the 6th of December of that year there was a great collapse of the surface over the Kent and Naylor's mine and Tomkinson's, and the Cranage Brook, which flows over these mines, found its way down through the old top mines into the bottom mines, and from them through the thin partition wall, which had been pierced twice before, into the Platt's Hill mine. This latter mine was being worked, and was not an abandoned mine. It covered over 15 acres in extent, and was about six yards high. All the water from the Cranage Brook, which is a large brook, as well as all from the Wadebrook and a great deal from the river Weaver ran for many hours into the Platt's Hill and adjacent old mines, and the whole overlying district was violently disturbed and much destruction of property took place. This subsidence was by far the largest that has ever occurred in the North-

wich district, and its results have been very disastrous. A rapid subsidence of the overlying land occurred, and a large lake was formed, which has gone on increasing ever since. This subsidence, after the first inrush of water, was not of a violent nature for a long period. It depended, of course, upon the amount of pumping that took place out of the mines. In 1893, another change took place, the quantity of brine pumped out of the Dunkirk mines was enormously increased, and the usual result soon followed. The land began to sink more rapidly and very soon the lake, which had been gradually forming, approached the shafts of the Platts Hill mine. The old mines were pumped down, and the Platts Hill shafts collapsed, forming a considerable hole. This, as far as I could measure it, was about 90 feet by 15. Shortly afterwards the land sunk sufficiently to let in the water from the neighbouring lake which had formed. No sooner had the water got a free passage to the shafts of Platts Hill, and through them to the mines below, than the most serious destruction of land commenced. Although the shafts had been practically filled with rubble and other material, the fresh water cut away the salt and made a passage which got wider and deeper. At one time the depth of water over the shafts was fully 200 feet, and for a long time it remained above 160 feet over a considerable area. The earth on all sides slipped into this enormous cavity, and attempts were made to choke it by sinking old canal boats full of cinders over the shafts, and by putting in thousands of tons of dredgings from the Weaver and Ship Canal. Fully 100,000 tons of earth and rubbish have been put in, and more than a quarter of a million tons of earth have slipped in, but yet there is a depth of from 60 to 80 feet over a considerable area, and the land is still cracking and slipping in. On the westerly side of the hole the sinking is so rapid and so great that it seems certain the

subsidence has reached some of the old top rock mines abandoned over a century ago. The enormous quantity of water that has gone down has literally flooded all the underlying strata, and the brine now stands at a level of some sixteen yards above the surface of the top rock salt. The result of the saturation of this water is apparent, and a lake of over twenty acres in area and of a depth from one foot up to fifty or more has been formed since 1880. The Marston or Neumann's Flash is more than twelve acres—it is very deep in parts. Both lakes are constantly extending.

There are ten flooded mines all connected in the Marston district, and these cover an area of more than sixty acres. There are also ten flooded mines in the Dunkirk district, and these cover about sixty acres also. Between these two sets of mines, so similar in area, there is for a long distance only a narrow barrier of rock salt, which at any moment may be penetrated or eaten through by the fresh water, and which barrier has once been pierced and the hole plugged again.

In one acre of fully saturated brine, having a depth of fifteen feet (the least average of a rock salt mine), there are 6,000 tons of salt. In the sixty acres of each of these districts there will be 360,000 tons of salt, or 720,000 tons in the whole. Reckoning one and a half tons of salt to the cubic yard, it will have taken 480,000 cubic yards of salt, or, taking rock salt at 32 cwt. instead of 30 cwt., 450,000 cubic yards to saturate the whole of the brine in these enormous reservoirs. To supply this quantity of salt would require ninety-three acres one yard deep, or eighteen three-fifths acres five yards deep, the usual mine depth. It must, however, be borne in mind, that the average thickness of the two beds of rock salt is about

fifty-four yards; so that if the salt were all of average quality as regards the quantity of marl contained, and the water scooped all the salt out of both beds as it worked along, then one and three-quarters acres would suffice to supply the salt. The rock salt, however, is not equally free from marl, so that more than two acres would be required throughout the two beds of salt for this purpose. It is this enormous thickness of salt that causes the great depth of the lakes now forming. It is this thickness also, in the case of the top bed (about seventy-five feet), that makes it hopeless to expect subsidence to cease in any reasonable time if brine pumping goes on. To give some idea of the enormous reservoirs these mines are, it will suffice to say that it would take more than 500,000,000 gallons of brine to fill them.

I do not care to enter more fully into details, or I might point out cottages destroyed; salt works partially destroyed; new brine shaft, costing thousands of pounds and never used, rendered useless; and land swallowed up acre after acre. There are few places where the action of water can be more plainly seen than in the neighbourhood of Northwich, and when man's operations work with those of nature, as in this district, the result is worth the attention of geologists. What is taking place violently, and in a short time by the action of man, in Cheshire, has almost certainly taken place naturally, and during the course of ages, in other districts similarly situated.

It may be useful to put on record the bottom mines and their condition at the present date. It is very difficult to give the exact areas, but those given are approximate, and certainly not excessive.

I. *Dry Mines, Working or capable of being Worked.*

		Acres.
1.	Baron's Quay, Leicester Street	20
2.	Witton Hall, Warrington Road..	12
3.	Penny's Lane, Station Road, Witton	3
4.	Neumann's, do. do.	2
5.	Williamson's, Wincham..	4
6.	Neumann's, Ollershaw Lane, Marston	8
7.	Crystal, Marston	3
8.	Fletcher's, do.	5
9.	Adelaide, do.	16
10.	Pool Pit, do.	6
11.	Marston Hall, Marston	30
12.	Marston Old Mine, Marston	40
		149

This is a minimum quantity, and the probability is that 170 acres would be nearer the mark. The only mines being worked at the moment are Baron's Quay, Adelaide, and Marston Hall.

II. *Flooded Mines in Dunkirk District, all connected.*

1.	Ashton's (old bottom mine)..	About 60 acres.
2.	Tomkinson's	
3.	Kent and Naylor's	
4.	Platt's Hill	
5.	Barton's (old mine)	
6.	Thompson's	
7.	Barton's new (Blackwell) ..	
8.	Worthington's..	
9.	Wakefield's..	
10.	Marshall's	

III. *Flooded Mines, Marston District, all connected.*

1.	British	About 70 acres.
2.	Wincham (Steenstrand)....	
3.	Gibson's	
4.	Broady	
5.	Hatfield	
6.	Reynolds and Dignum	
7.	Chantler	
8.	Neumann and Ellson's	
9.	Blackburne's (old)	
10.	Blackburne's (new)..	

IV. *Flooded Mines, Isolated.*

1. Caldwell's, Witton, near Weaver.
2. Swinton and Bleases, Witton, near Top of Brook.
3. Ashton's (new), Dunkirk.
4. Worthington's, Witton, near Worthington's pumping station, Dunkirk.
5. Littler's, Marston.

These are all comparatively small mines not exceeding 20 acres in the whole.

Mr. De Rance said: I have very great pleasure in moving that a vote of thanks be given to Mr. Ward for his paper. Everyone here knows that he has given a great deal of attention to the subject, and he has been very assiduous in collecting and preserving those old records which have proved so interesting. Any remarks I may have to make upon the subject of the paper I will reserve to a later stage.

The motion was seconded by Mr. Wells, and cordially passed.

Mr. WARD having acknowledged the compliment,

The CHAIRMAN invited discussion. He said: This paper must have cost Mr. Ward a great deal of trouble in the preparation. It is a very intricate subject and has been very elaborately dealt with. The paper sets forth that not only are the ordinary difficulties of mining to be contended against, but there is the action of water, dissolving the very structure of the mine, when it can get access to it. The subject is a very interesting one. I observe from one of the sections that at one point gravel was met with in association with the rock salt. This, I think, is unusual. I would like to hear more from Mr. Ward about it—that is to say, whether this really is a pebble bed associated with this rock salt, or whether the presence of the pebbles is owing to some slip from the upper part of the shaft or bore hole, or has been dropped in. There is another point. Mr. Ward attributes to natural forces the access of water to the rock salt mines, and also the entrance of large bodies of brine from the rock head to the rock salt mines below. I should like, if he will kindly say in his reply, whether many of the old shafts are not very carefully secured to prevent brine from flowing down into the workings, and whether anything has been done in dealing with that anomaly of treating brine as though it were water, and not something of more importance than water, seeing that it contains 25 per cent. of salt. Similar mineral solutions of copper are found in some old copper mines, where water gets access to them. The water dissolves a portion of the copper. This is pumped, and the copper is precipitated from the water by iron. But that is not treated as water. It is treated as mineral working, and the copper so extracted pays ordinary royalties. I see various gentlemen present who may give us their views on the subject of the paper. Mr. De Rance,

I know, is an expert upon it, and the meeting will be pleased to hear any remarks from him.

Mr. De Rance, after expressing the indebtedness of the Society to Mr. Ward for the admirable précis he had given them of the various opinions which had from time to time been put before Local Government inquiries and Parliamentary Committees, said: The paper—Parts I. and II. taken together—may be divided into two portions. There is a portion of each, in each of the two parts. One is what you may call the ancient history of salt mining, and I take it there is no one in Cheshire who has done more useful work in endeavouring to preserve old documents, and to ferret out information, than Mr. Ward has. Our thanks are greatly due to him for his work in that direction. I do not know that he has told us anything that is absolutely new to-day, but we owe him our thanks for presenting the information he possesses in this handy form. There are one or two points upon which I would like to offer a few remarks. When the first part of Mr. Ward's paper was read, in June last year, I happened to be in London, but I see from the published report that Mr. Atkinson, H.M. Inspector of Mines, and Mr. Joseph Dickinson, ex-chief Inspector, both spoke of the importance of having the plans of mines in the Northwich salt district carefully preserved; and Mr. Atkinson suggested that they should be deposited at the Home Office—which no doubt is the proper place. I have, from time to time, in relation to various inquiries I have made for the Salt Union, so far as was in my power, reduced on to the twenty-five inch Ordnance Survey all the plans of the various mines which could be got hold of—the black, at the time the map before you was made, in 1891, representing the flooded mines; the yellow, so far as the Witton district is concerned, still represents the dry mines; but that colour, as regards the British mine—as Mr. Ward

pointed out just now—would, if the map were to be made now, also be black. Northward of that we have the Marston area, where, I am glad to say, the mines are still dry; and still further west is the Baron's Quay mine which Mr. Ward referred to. I am sure no one appreciates the value of Mr. Ward's paper more than myself, but there is one curious thing about it. There is not in Part I., as printed, nor so far as I heard, in what Mr. Ward has read to-day, any reference to the Salt Union. Mr. Ward is a Director of the Salt Union, and in the year 1890, I think it was, I was appointed their expert geologist, a postion I have held from that time to the present; and the first recommendation I made to the Salt Union was that the shafts in the whole of the Cheshire district owned by them—and, if possible, also those which they did not own—should be levelled. Here is the record of that levelling, done by Mr. Bancroft, of this city. I also reported to the Salt Union that it was exceedingly desirable the thickness of this rock salt should be ascertained—the upper and the lower beds—and the Salt Union agreed to that also, and Mr. Rigby most efficiently carried it out in three weeks, in January, 1892. He determined the thicknesses of both beds. Those thicknesses were correlated with the levels obtained by Mr. Bancroft, and certain figures were obtained which appeared upon the first sheet of Mr. Ward's paper—Part I. I have no doubt it is an accidental oversight on Mr. Ward's part, but anyone reading this paper, and not knowing the facts, would not know how the figures came into existence. I have checked these figures and they work out to a decimal point; therefore there can be no doubt as to their origin. In relation to the question of the level of the rock-salt the six-inch map now exhibited was plotted, to represent the underground contours of the rock salt, in which the pink area shows the crown of the boss, the dome, or ridge of the rock salt,

which Mr. Ward has very clearly put to you as being less than 50 feet below Ordnance datum, in a certain area near the Canal, sloping away to the western area which is 120 feet below Ordnance datum, and sloping away equally on the eastern side to 120 feet. We all know Mr. Ward's great experience as a salt maker and miner, in practical work, but we geologists, have a very great interest, as you all know, in glacial matters—glacial drifts, pre-glacial valleys, and all that sort of thing; and I do not quite follow, in this paper, the fact of the absolute cutting out of both beds of rock salt by the pre-glacial valley, and the filling in with drift. I remember being cross-examined by Mr. Pember before the Special Committee of the House of the Commons. He said: "It is all very fine, you have a borehole at Riversdale, and this No. 4, but you have not got the other side of it." Well, it is a most interesting thing, I have found the other side of that this last week. It is shown on the section now before you—the last plate of vertical sections published by the Government Geological Survey. It has been arranged both geographically, and as regards the brine levels, by myself.—(Mr. De Rance described this section in greater detail.) The brine levels, he went on to say, are represented at different dates—thus the Winsford brine levels which are wholly natural, vary little. Carrying your eye along below the Ordnance datum (referring to the section), you may see how in the traverse from north to south you are continually cutting this pre-glacial valley. During the last few days I have added another column representing the new borings made for the purpose of obtaining water for the Winsford Sanitary Authority, and here again we have the same pre-glacial valley. The bottom of the valley all that way up the country is 84 feet below Ordnance datum. There are not, therefore, little pot holes occurring here and there, but links of a chain of a big story, which affects also the coal district

of Flintshire. Compared with this pre-glacial valley, old as Deva is, the ancient city of the Romans is perfectly modern. The old Dee went by the village of Doddington, four miles to the south, where it is 185 feet below Ordnance datum, and a little north, between Saltney and Flint, the whole valley of the Dee descends to over 200 feet. Before the Geological Society a few weeks ago it was pointed out that, as to South Wales and South Cornwall, there was the same story—all pointing to a time when this country stood higher than it does at present, and when the rivers cutting these valleys were some hundreds of feet lower than they now are. At Northwich, the brine levels are partly natural, as in the Marston district, but the greater part is "mined brine," from the bottom of the old rock mines, and is dependent on entirely artificial conditions. From time, as the brine is pumped out, the roof collapses, the streams flow in, and sudden rises of brine take place, to a level below that of the Weaver, of the amount of difference between the specific gravity of fresh water, and the latter mixed with brine. I have troubled you with these details because I am sure Mr. Ward must be wishful to give other people credit for work done. At the same time the Society must feel that I wish in no way to depreciate the most valuable work Mr. Ward has done in collecting together so much valuable information which, but for him, might have been lost for ever.

Mr. Gerrard said: I have only two thoughts with regard to this very interesting meeting. I have already said what I thought as to the value of Mr. Ward's papers, and how we appreciate them; but in time to come they will be very much more appreciated, as being historically accurate records of matters, respecting which information would otherwise be unobtainable. The first thought that occurs to me is with reference to the desire expressed by Mr. Atkinson for the safe deposit of these plans. If Mr.

Atkinson were here he might be disposed to say that what remains for Mr. De Rance to do—or for the Salt Union to do—is to place these valuable plans beyond all chance of being lost. The plans are, no doubt, now in safe possession, but Mr. Atkinson's idea evidently was that they should be placed beyond all possibility of being lost, and secured, as plans under the Coal Mines Regulation Act are secured, for all time. I am pleased to say that the last Act in connection with coal mining went beyond any previous Act in giving power to get possession of all plans that can be got. Something of the same kind with reference to salt mines is what Mr. Atkinson aimed at. Members of this Society know what good work Mr. De Rance has done in the past, and we are all delighted to see him with us this afternoon, and hope to have him here many times. My second thought is rather a practical one, in connection with the working of salt. I listened to Mr. Ward's admonitions about the pillars with very great interest. I did not quite gather what is the most modern view with regard to the areas, or dimensions, of pillars, in proportion to the salt worked out, and I should be very glad if Mr. Ward could give us that information. It is well known that in addition to that of Cheshire there are other salt fields now being worked. At Fleetwood the salt deposits are proving very valuable; a large amount of rock salt has been obtained from there. Then we have had from Professor Boyd Dawkins information about the Barrow salt field. Let us hope, with regard to these new salt deposits, the same mistakes in working will not be made as have been made in Cheshire in the past.

The CHAIRMAN asked Mr. Gerrard if he could, without breach of confidence, state what was the greatest height of rock salt being worked at Fleetwood and in the Irish mines.

Mr. GERRARD: I would not like to say from memory.

When I was last at Fleetwood—only a short time ago—they were still opening it out. They had not reached the bottom.

Mr. De Rance, referring to Mr. Gerrard's observations, said: Copies of the maps now on the table have been in the Geological Survey Office for some years, and they are in very good keeping there. It would no doubt be useful if copies were also preserved at the Home Office.

The Chairman: I some time ago suggested to Mr. Ward that he should deposit these numerous plans in the Mining Record Office, of the Home Department.

Mr. De Rance: That would be the proper home for them undoubtedly. I may mention that I have had the opportunity of going down the Fleetwood shaft very slowly indeed, and have examined it from top to bottom. It has one remarkable feature, which I have never seen in the Cheshire salt district—the nearest approach to it is in the sketch which Mr. Ward has given us, and which suggests current bedding. This, in the Preesall mine, exists in the rock salt itself, the curved structure being distinctly visible.

The Chairman: The roofs of the old salt mines of Cheshire when dressed with the pick showed distinctly a globular structure in the rock salt.

Mr. De Rance: Yes.

The Chairman: And were they as carefully dressed now as in olden times, instead of being blasted with powder the circles would be distinct enough.

Mr. Lionel B. Wells: I can only echo what Mr. De Rance has said,—that Mr. Ward's papers are valuable, and will be more so in years to come, and it is most important that the plans and sections should be in public keeping for reference hereafter. We have many of us been

engaged in discussions on this question, and these plans and sections not being generally available it led to a good deal of turmoil and many public inquiries. I think we should have had fewer of them had the information been forthcoming when we started on our quest. It proves to me the advantage of information of this description being accessible to all whom it concerns.

Mr. De Rance illustrated on the black-board the curved structure seen in the Preesall beds.

Mr. Stirrup: Is that due to some secondary cause?

Mr. De Rance: I cannot pretend to say.

Mr. Stirrup: Because otherwise that would upset the recognised theory as to the formation of salt deposits by the evaporation of sea-water.

Mr. De Rance: Quite so.

Mr. Stirrup: I think they must have their origin in some secondary cause. The salt deposits of Cheshire are presumed to resemble those in other parts of the world so far as their mode of accumulation. Lately I came across a statement with regard to some borings in Germany where, to the south of Berlin, they have deposits to a depth of over 4000 feet. One bed has actually been proved which is nearly 4000 English feet in thickness. That seems extraordinary, and if the explanation which is generally accepted as to the origin of rock salt deposits is correct, what a vista this opens out of the years it has taken to form a bed of such amazing thickness. Of course the generally recognized theory is that the salt has been formed by inroads of sea water into depressed basins, and that this process has been continuous, so that, owing to evaporation, you have deposit after deposit, until a solid mass has been formed. When therefore you find a mass 4000 feet thick, it means

that there must have been an incalculable space of time during which that accumulation took place.

Mr. WELLS: I have seen a series of borings through the salt deposits showing a bed 800 metres thick, which approaches the 4000 feet mentioned by Mr. Stirrup.

Mr. STIRRUP: Where is it?

Mr. WELLS: It is in Mecklenburg, about 50 miles south-east of Hamburg, near the Elbe. There was a great depth of pure white salt.

Mr. STIRRUP: These Prussian deposits are the thickest known in the world.

Mr. HOLROYD was asked by the Chairman if he could throw any further light upon the subject. He said he would not like to express an opinion until he had examined the subject more closely. The pebbles exhibited, he added, resembled hardened clay slate more than anything else he could think of. Perhaps Mr. Ward would tell them whether there were any special circumstances to account for their getting into the salt.

Mr. RIGBY: I do not know that I shall add anything to what Mr. Ward has told us in his paper; but, with regard to pillaring, it has always seemed to me that the dimensions of the pillars must be regulated entirely by the extent of the mine. At the Barron's Quay mine, which is about 45 acres, the pillars have been left from the first about twelve or fourteen yards square, and they seem to be sufficient; at any rate, I do not know any part of the mine which is giving way at all. Mr. Ward has pressed a great deal into his paper, although, as he will admit, there is much more that might be said.

The CHAIRMAN: In my original report on the salt districts, I went a good deal into the question of the size of the

pillars. Some had crushed in different mines. I found that at Winsford they were beginning to leave the same size of pillars as at Northwich, without considering that their mine was considerably deeper; and as soon as I hinted this to the then owner, he at once enlarged the size. In Ireland they were arranging pillars the same size, and at considerably greater depth than at Winford; their mine was about 300 yards deep, and they were not making any allowance for the much greater superincumbent weight which the pillars had to carry. A hint there, again, induced them to amend. In the first mine opened at Carrickfergus the dimensions of the pillars were the same as at Northwich; and the consequence was that they crushed. I drew out a table of the crushing weights that I thought suitable for the various depths, but since then they have extended the height of working considerably in some of the mines. I understand that they have got to a height of 70 feet of working.

Mr. Rigby: At Duncrue, Carrickfergus, at present, we are excavating 46 feet high, and leaving pillars 45 yards by 15 yards.

Mr. Ward, in his reply, said: I have to thank Mr. De Rance for calling attention to some of my sources of information; at the same time I have also to say that I have had to correct a good deal of information which has been given by a great number of people, and hitherto relied on as accurate. I quite agree with Mr. De Rance's observations as to the levels and other things, but unfortunately no two sets coincide. I can easily understand this difference, as can anyone who has to do with the working of mines, and likewise the differences in the measurements of depths. Through the stretching of a cord or other circumstance it is easy to get a variation of a yard or two in a shaft of great depth. I can only say that I have done my best to ensure accuracy.

Mr. De Rance's levels, I may remark, are all exceedingly good; I accept them absolutely. Although I belong to the Salt Union, for whom they were made, I should explain that I was not on the Committee which had the direction of that work, therefore the information was not given to me; but I have endeavoured to give what I knew to be facts, which I had gone into, and, barring the matter of a figure or two, anything I have given in the course of this paper may be taken as correct. Mr. De Rance has gone to a great deal of trouble; and his labours have been wonderfully successful; but I have never been a strong believer in the theory of a glacial valley. It is not borne out by any evidence that I have seen. I have done my best to get at all the facts, and to correlate all the evidence available with reference to the salt deposits, and I think I know the district as well as anyone, having made a study of it for the last thirty years; I have tried to get all information of an historical character, some of which has never been published before. Many of the maps I got from first authorities—from the men who made them long ago. With regard to the brine levels at Winsford and Northwich, I find them so variable that it is impossible you can take them as a basis for anything. They fluctuate according to the amount of pumping. The normal level in the Northwich district was at one time close to the surface; now it is below the rock-head altogether. As to pillars, we are leaving them all larger. Experience has taught the necessity of this. The beds of rock salt are, as Mr. Stirrup has pointed out, enormously thick in many places, but after all the study I have given to the subject I cannot come to any other conclusion than that rock salt is a deposit from water. There is not the slightest doubt upon that point in my mind. Everything now being done in the way of deposition is being done in salt lakes. The Hungarian

mines afford evidence of wood having floated in during the period of deposition; and insect remains have also been found. As to those peculiar curves, to which Mr. Stirrup referred, I am unable to say much; but I think they must have been caused by the action of water. The mixture of marl with the rock salt of Cheshire is sufficient evidence on the question of water deposition. The rock salt passes into the marl, pure and simple, both above and below.

The CHAIRMAN said: With regard to the formation of mineral, that is a subject we all like to speculate upon. It is simply speculation, because, after all, you have to go back to the original problem—Where did the salt come from? It is just as likely that the sea derived its salt from the rock, as that the rock salt was formed by the evaporation of sea water in flooded areas.

Mr. WARD said with regard to the pebbles found at Riversdale, they were in the boring, and were brought up by the tube.

The CHAIRMAN: Then as to the anomaly of treating this valuable brine as "water" pure and simple, seeing that it contains 25 per cent. of salt?

Mr. WARD: I do not believe brine comes under the law as to "water" at all.

GIFTS TO THE SOCIETY.

The CHAIRMAN said that Mr. De Rance (who had been obliged to leave the meeting) desired to present to the Society a lithographed portrait, now exhibited, of the late Sir Henry de la Beche, the original Director of the Geological Survey, when it had its head-quarters in Jermyn Street, London. As far as he (the Chairman) could recollect of Sir Henry it was a very good portrait. Mr. De Rance also presented a copy of Elias Hall's Geological Map of Lancashire. It was, at the present day, more of a curiosity than anything else. When it was constructed the coalfield was comparatively little known.

Mr. WARD in moving that the thanks of the meeting be given to Mr. Dickinson for presiding, said that Mr. Dickinson had done more to elucidate the salt question, and all connected in brine pumping, than any other living man, his researches being embodied in valuable Blue Books.

Mr. RIGBY seconded the vote of thanks. He remarked that Mr. Dickinson's first report, of 1873, was a standard of reference for those interested in the salt trade. It was astonishing how his inferences had proved correct. His diligence in the preparation of that report, as well as accuracy of detail, was extraordinary.

The vote of thanks was unanimously accorded, and Mr. Dickinson briefly replied.

This concluded the business of the meeting.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XX. VOL. XXV. SESSION 1897-98.

WIGAN MEETING.

The ORDINARY MEETING of the Members was held on Friday, May 13th, 1898, in The Mining School, Wigan.

The President: Mr. JOHN RIDYARD, F.G.S., in the Chair.

NEW MEMBERS.

The following gentlemen were balloted for and duly elected Ordinary Members of the Society:—

Mr. JAMES LOMAX, 65, Starcliffe Street, Moses Gate.

Mr. THOMAS ROSCOE, Peel Hall Collieries, Little Hulton.

ON THE COAL INDUSTRY OF THE RHENISH-WESTPHALIAN PROVINCES.

By Mr. HENRY HALL, H.M. Inspector of Mines.

Mr. HALL said: "I feel that some apology is due from me for presuming to deal with the commercial aspect of coal mining, but this Report came into my hands, and it

struck me in looking through it that it was a very interesting one. Perhaps few people in the coal trade have seen it, and what I propose to do is to read most of the Report, and then to make a *precis* of what is in it with a few observations. The Report is on the coal industry of the Rhenish-Westphalian provinces, by Her Majesty's British Consul, at Düsseldorf, Mr. T. R. Mulvany, received at the Foreign Office, March 5th, 1898."

Mr. HALL, having read copious extracts from the Report, made the following observations:—

"We see that in Westphalia, as in Britain, the existence of a rich coal-field ensures industrial success. In Prussia, as we travel on the main lines towards Berlin, we probably see a greater show of industrial activity than can be seen in any single district of our own country. The Consul describes it as 15 or 20 miles of collieries, factories, and railway sidings, illuminated by the electric light, and having the appearance of one long continuous industrial town. My own impression, in passing through a year or two ago, was that we have nothing equal to it in England. The Consul's observations on the combination of employers to regulate the selling price of coal are very interesting. We have first the fusion of all the small firms into two or three large companies, then the combination becomes practicable and effective. We are told that 90 per cent. of the Westphalian collieries are now combined, representing an output of 35 million tons, and that reckless competition has ceased, that the trade is held well in hand, and that the combination has proved of incalculable value, not only to the coal trade itself, but also to the iron and steel and trade in general. The syndicate does not ask for the highest prices that could, under the circumstances, be obtained, but only such as the industrial consumer can afford to pay, and probably this fact accounts in a great measure for the success

which has attended its operations. We are told that substantial profits are obtained notwithstanding the high and increasing cost of working due to deeper mines, more onerous government regulations, higher wages, a lessened production per man (which latter always appears to follow higher wages), the large increase of expenditure on screening and cleaning, which in Germany is most elaborate and complete, and the increasing cost of compensation for injuries. All these items are a more serious charge in Germany than in England, with, perhaps, the exception of wages, which at a typical Westphalian mine are approximately as follows:—

Coal getters.. ..	4s. 2d. per day of eight hours.		
Stonemen	4s. 4d.	do.	do.
Repairers	3s. 3d.	do.	do.
Putters	2s. 5d.	do.	do.
Horse drivers ..	2s. 0d.	do.	do.

but the Consul tells us that the British collier puts out twice as much work as the German. In addition to the satisfactory returns in the shape of profits at the years end, there has been also an increase of confidence in coal mines as a safe investment for capital, thus enabling money to be obtained for extensions on easier terms. It is quite clear from the tone of the Report that our English Consul has been, and is most favourably impressed with the operation of this combination or syndicate. I have the pleasure of Mr. Mulvany's acquaintance, and in my opinion he is a man quite capable of forming a sound judgment in a matter of this kind; moreover, the figures he gives are of themselves convincing, I think, of the fact that with greater difficulties to overcome, the Westphalian mine owners have achieved, latterly, greater success and more profitable results than their English competitors. The combination which has enabled them to do this was, we are

told, only made effective after prolonged and persistent agitation, by means of which the support of the railways was secured. We are also told that it has done good in every direction, and that it promises to be permanent, its operation is confined to the sales department and out-put, having no control and taking no responsibility for the working of the collieries. In England we are disposed to look askance at combinations of this description, and to picture all kinds of evils and ultimate damage to general trade as the probable outcome; but the truth of this view is certainly not borne out by the Report I have read to you. The Consul expresses the opinion "that in England, Scotland and Wales, co-operative action is rendered difficult by the number of coal districts to be united, but it has got to be done in one form or another." The German scheme seems to provide just that steadying hand which we appear to lack, and hence with an ever growing demand for the commodity we produce our trade continues to be unremunerative."

The President said it was their duty to thank Mr. Hall for bringing the subject before them. Mr. Hall said it was not his business to go into the commercial part of the question, but it was the business of someone, and very often what was everyone's duty was no one's duty. He thought that when the paper was printed and circulated amongst their members it might be the means of stirring up some of their leading men in the coal trade. They had made one or two attempts to form a combination in the coal industry to regulate selling prices, but they had not arrived at anything of a definite nature. He hoped something in that direction would be done soon, as everyone in the coal trade knew that the mining industry was very much depressed and that profits were nil. He begged to propose a hearty vote of thanks to Mr. Hall.

Mr. G. Caldwell, who seconded the motion, said the efforts which had been made for a combination had not been successful in this part of the country; but they would have to go into the matter in some such way as the one mentioned by Mr. Hall, and the sooner the better, because it was no use disputing the fact that while in Westphalia they could make those enormous profits they could not in this country make ends meet. He had great pleasure in seconding the vote of thanks to Mr. Hall for his paper, which was intended to serve their best interests.

Mr. Burrows said he was very much obliged, with the rest of them, to Mr. Hall for placing that subject before them. Sometimes a candid friend did a lot of good. He was quite certain that in Lancashire they made the competition themselves, and it only wanted the least bit of self denial and common sense to regulate the thing. He did not say they should go in for enormous profits, but they should prevent those everlasting drops of a penny here and a penny there. There seemed to be constantly decreasing prices, and it appeared to him that in Lancashire it was absolutely unnecessary. A little bit of firmness, and not that desire to follow everyone who reduced the price would have a good effect. Instead of that, if someone was reported to have dropped the price, down went everyone else without a murmur. Those who wanted a low price would soon get tired. He thought the coalowners were a little nearer to becoming united, but were still a long way off. They agreed upon general principles, but when it came to apply them they failed. When the men got better united they would make them pay more for the coal they got, and if the colliery proprietors did not get more from the consumers they had no one but themselves to blame. It struck him that in Westphalia they were in a somewhat favourable condition. If they wanted to raise more coal it did not

seem that their facilities were great enough to enable them to do it. In 1893 a Sales Association was formed to steady the price of coal at a very excited period and when the demand was very keen, but as soon as the demand began to fall off and the production increased they broke away one after the other. That was the difficulty they had to fear. People did not want to lose anything. They, however, saw what they could get in Westphalia; but perhaps they could not increase the production as we in England could. However, it was a valuable lesson, and he hoped something would be done whereby an alteration would be made in this country. They got the least return for their capital of any staple trade in England, and it was all the harder to him because it was entirely their own fault, and he was sure it could be altered.

Mr. Tonge inquired if it was a ten hours day or an eight hours day for the 4s. 2d.

Mr. Hall: Eight hours all round.

Mr. Brocklehurst said he would like Mr. Hall to tell them the basis on which those syndicates were formed. Mr. Burrows had alluded to the formation of the Sales Association just after the strike of 1893, and had stated it was a failure. There was no doubt the fact of that being a failure was owing to the different owners being allowed to make their own sales. As he took it, it was regulated differently in Westphalia. He remembered reading about that Westphalian matter when it was first instituted. The coal-owners there were in the same position as the coal-owners in this district. They competed against each other to such an extent that profits were nil. They were compelled to do something—cease operations or go into bankruptcy—to find a way out of their difficulties. That they had found a way out of their difficulties was evident. Their scheme had been a success, and undoubtedly was worthy of every consideration.

Reference had been made to the Westphalian output. If he remembered rightly, the output had been increasing at a greater ratio than in England during the last few years, and that notwithstanding the operations of the syndicate. Taking Lancashire for instance, they knew as a fact that they consumed all their coal, probably rather more. Of course they were subject to competition from the Yorkshire, Derbyshire, and Nottinghamshire coal-fields, but they suffered equally as great competition in their own centres from the suicidal competition which took place among individual owners, and there was no necessity for it. If only a scheme could be devised like the one in Westphalia, he, for one, did not see why it should not be carried into effect, and be equally as successful in this country. He had great pleasure in supporting the vote of thanks to Mr. Hall, who had evidently shown greater interest in the subject than the coal-owners themselves.

The motion was heartily passed.

Mr. Hall, in acknowledging the compliment, said it was perhaps presumptuous on his part to deal with that subject. He did not mean to tell them of their faults, but only what was being done in other countries. They might take it home or not. With regard to the production in Germany increasing more rapidly than in Great Britain—from 1892 to 1896 the production in Great Britain increased from 184,000,000 to 195,000,000 tons. Great Britain now yielded 202,000,000. Germany had jumped from 71,000,000 to 85,000,000; they had increased very rapidly in Germany. America had jumped from 145,000,000 to 175,000,000, France from 25,000,000 to 28,000,000, and Belgium 19,000,000 to 21,000,000 tons, so that America, Germany, and England seemed to have developed most rapidly. He remembered speaking to a German about the combination, but he could not recollect whether he said they took the

actual sales entirely in their own hands, or it was left to particular collieries to make their own sales; but, at any rate, the Syndicate fixed the prices.

He (Mr. Hall) remembered that the Chairman of the Syndicate told him the greatest difficulty they had was English competition, selling coal at prices which left almost nothing in England to the coal producer.

The CHAIRMAN: Would it be possible to formulate a satisfactory scheme?

Mr. HALL: Yes.

Mr. CALDWELL: The scheme is pretty well known. Pamphlets were published, and I believe all the sales were intended to be effected through one office.

Mr. HALL: I have an idea that was so.

Mr. BROCKLEHURST: They are regulated through a central office?

Mr. CALDWELL: Yes.

Mr. HALL: You can get any particulars you wish from Mr. Mulvany, our consul.

Mr. SAINT: I should like to draw the attention of the meeting to a general system in vogue in the United States of America, where it is a common practice for producers to combine for the purpose of regulating the selling prices. A central office is formed, under the control of the Management Committee, who arranged the prices, and all the accounts passed through that office, but each member finds his own customers, and executes his own orders. That seemed to be a very simple plan, and one worthy of consideration.

Mr. HARRISON said to form a combination and let each colliery firm send a man on the exchange as at present, except he was only to sell at a certain price, would not do

away with the difficulty, because many men had to buy large quantities of coal, and it depended how much commission they got as to who received their orders. If one firm would give twopence and another would give sixpence, there was a difference of fourpence in the price at once. The accounts passing through a central office would not do away with a lot of underhand scheming, and while sellers had to seek their own customers they would have different ways of varying the price per ton.

ON AN IMPROVED DECKING TABLE FOR FACILITATING THE LOADING OF PIT CAGES.

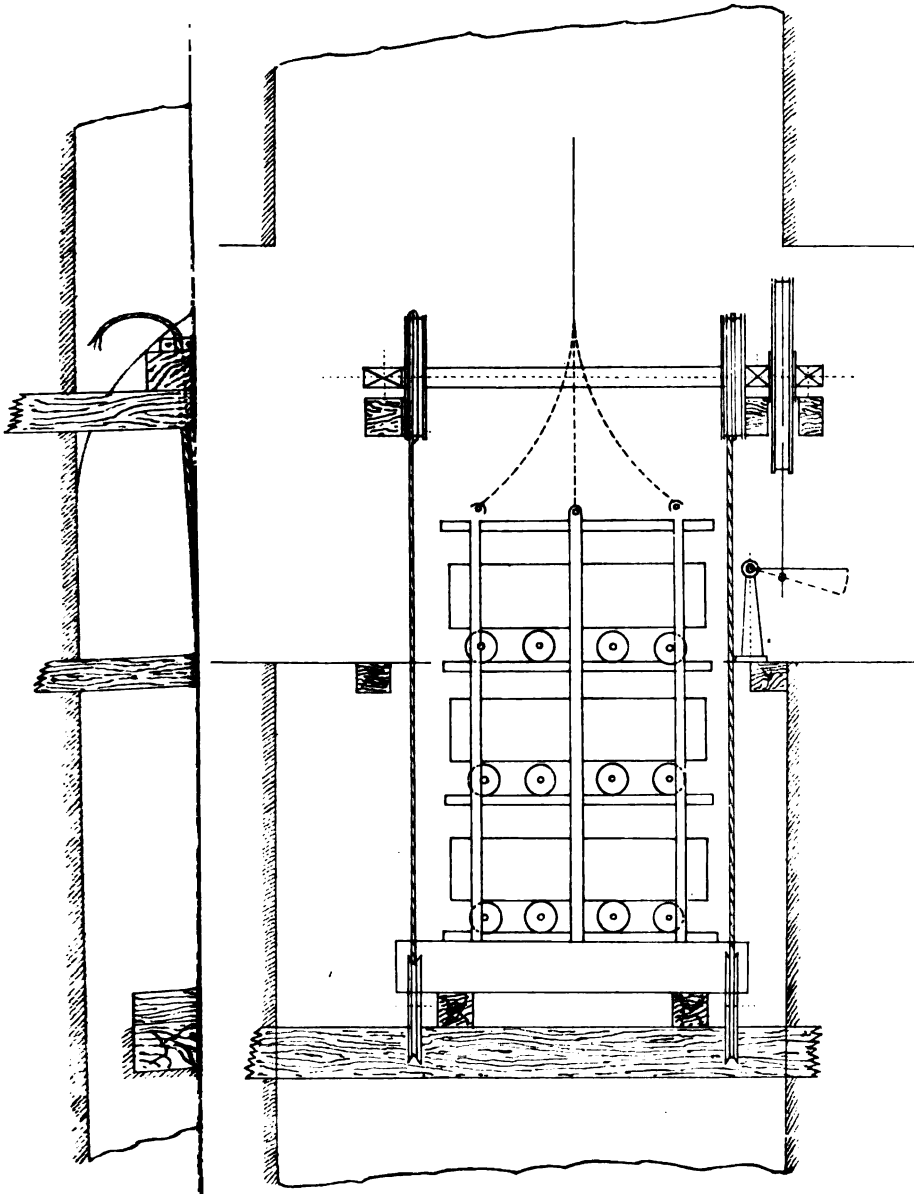
By Mr. William Saint, H.M. Inspector of Mines.

The principal object of this communication is to furnish the members of the Society with a short description of a new arrangement of balanced tables for facilitating the loading of pit cages in the shaft.

The apparatus, which is illustrated in the accompanying drawing, was originally designed for use in mid-shaft where it was desirable to use a cage balance for decking purposes without impeding the passage of the ventilating current to the lower mines; but it is obviously equally applicable for its purposes at the shaft bottom. It is the invention of Mr. John Tinsley, Mechanical Engineer at Ashton Moss Colliery, where it has been working most satisfactorily during the last two years. It consists of two platforms or tables within the shaft, upon which the cages alternately come to rest. Each table is fitted with two grooved pulleys, one at each

end, which revolve at right angles to the table. At a height of about eight feet above the loading level, to which the tables ascended in turn, an iron shaft is mounted in suitable bearings and affixed thereon are two grooved pulleys in correspondence with the pulleys on the respective ends of the tables. The tables were suspended on the grooved pulleys by two compound steel wire ropes. One end of each rope was firmly secured to a bearer and passed underneath the pulley of the table shown at the loading level, thence upwards to the farther side of and twice or thrice round one of the shaft pulleys and beneath one of the pulleys of the other table, shown in its lowest position, and terminated in an eye bolt, for adjusting purposes, fixed in a bearer on the opposite side. By so arranging the ropes the two tables balanced each other. The iron shaft also carried a brake wheel which was fitted with powerful brake straps and blocks, and also with the necessary levers in a convenient position for the on-hooker who controlled the motion of the platforms during loading operations. At first one of the tables was caused to come in line with the loading level and the brake was then applied. The descending cage dropped on that table, and the winding engineman allowed the rope to run slack. To lower the cage and bring its several decks in line with the loading level the on-hooker gradually released the brake. The weight of the cage, &c., gradually depressed the table and caused it to sink until the next deck reached the loading level when the attendant applied the brake again. For the next deck the operation was repeated. Meanwhile the other table had been gradually raised to the loading level, and was ready to receive the other cage, which, on alighting, repeated the operation, and in that way the lowering of one table prepared the other for working. The motion of the pulleys being two to one of that of the tables it would be understood that the brake power was correspondingly increased. The

Trans. Man. Geo. Soc. Part XX. Vol. XXV.
to illustrate Mr. William Saint's paper on
Tinsley's Patent Decking Table for facilitating the loading of Pit Co



SIDE VIEW.

ropes, in addition to supporting the tables, acted as effective cushions for the cages, and, in the event of the cages being allowed to fall heavily upon them, the ropes slipped round the fixed pulleys and thus prevented damage to the cages and their contents. Either table could be readily removed by means of a chain attached beneath the cage, then raising it a few feet and slinging it into the mouthing. When the lower cross bearers were removed there was a clear way for the passage of the cage to greater depths for examination and other purposes.

Mr. TINSLEY exhibited a model and fully explained the working of the tables.

The PRESIDENT: Is there any balance weight?

Mr. SAINT: No, the tables balance each other.

Mr. HALL: Does it save any time?

Mr. TINSLEY: From 10 to 12 seconds each winding.

Mr. ROBINSON: How long does it occupy to remove the tables, lower the cage in the shaft for examination purposes, and to return and replace the tables in working order?

Mr. TINSLEY: Three-quarters of an hour.

The PRESIDENT said their thanks were due to Mr. Saint for his notes, and to Mr. Tinsley for showing the model. He remarked there was an advantage in the way Mr. Tinsley had designed the apparatus.

Mr. HARRISON, who seconded the motion, said he had seen the appliance at work, and he thought Mr. Tinsley had gained the object he had in view, which at the time Mr. Tinsley designed it, was to interfere as little as possible with the current of air to the bottom mine, and to be as handy to get down with the cage when anyone wanted to go to the

bottom. To have put in the ordinary decking table would have blocked the shaft bottom. He mentioned a case of over-wind, where an accident was averted by the appliance, and the men got out, not knowing anything was wrong, whereas upon the ordinary platform the cage would have dropped heavily, and the men would probably have been injured. It was a splendid appliance for its work.

The motion was passed.

A vote of thanks to the President for presiding closed the meeting.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XXI. VOL. XXV. SESSION 1897-98.

The ORDINARY MEETING of the Members was held on Tuesday, June 14th, 1898, at the Society's Rooms, Queen's Chambers, 5, John Dalton Street, Manchester.

The President, Mr. JOHN RIDYARD, F.G.S., in the Chair.

NEW MEMBER.

The following gentleman, having been duly nominated, was balloted for and unanimously elected an Ordinary Member of the Society:—

Mr. JOHN SAMUEL KRAUSS, B.A., Whitecot, Wilmslow, Cheshire.

FOSSIL REMAINS IN THE LANCASHIRE COALFIELD.

Mr. STIRRUP said: Some gentlemen will remember that a few years ago a circular was addressed to colliery proprietors and members of this Society who are interested in mining, urging the importance of a systematic and scientific collection of fossils from the coal strata of the Lancashire district. A committee was appointed, and although it has not latterly

shown much signs of life, it has been in existence for nearly six years; and during that time fossils have been brought here for examination from new sinkings, and from existing collieries, of exceedingly great interest. These have been named and tabulated, and an account of them will be found in the Society's Transactions, in papers prepared by Mr. Robert Kidson, F.G.S. The Keeper of the Museum at Owens College is now wishing to follow this matter up, having reason to believe that there are many new openings in the colliery districts for extending our knowledge of the flora and fauna of the carboniferous age. The College authorities are equally desirous with ourselves that all the knowledge which can be obtained—that is to say the scientific knowledge—from fresh sinkings, should be brought before this Society, and illustrative specimens reserved for the Museum, where they will be of benefit to the community at large. There may possibly be present to-day some gentlemen who are interested in these new sinkings; others who are engaged in mining operations actually in progress; and it is earnestly hoped that they will co-operate with the Committee. At the Council meeting this afternoon it was proposed that the Committee should start work again, and extend their investigations wherever new ground is being opened. Years ago there were opportunities in the Manchester district which were only partially taken advantage of. At that time—say 40 or 50 years ago—attention was given more probably to money getting than to the acquisition of scientific knowledge. Now it is desired to engage the interest of all in this work of tabulating the fossils from the different horizons of the coal measures, so as to get an adequate idea of what we have beneath our feet, even here in Manchester. The top beds have been worked out, I suppose, in many of our collieries; elsewhere they are

sinking deeper and deeper, and it may be that in some places these upper beds—which have the greatest interest for us—may be passed through. In all such cases we hope gentlemen will kindly bear in mind the work of our Committee.

NAVIGABLE WATERWAYS.

Mr. W. Saint, one of the Honorary Secretaries, called attention to a map, exhibited in the room, showing all the canals and navigable rivers of England and Wales. It had, he said, been compiled by Mr. L. B. Wells, a member of the Society. The relative depths of the streams which were navigable were indicated by lines of corresponding thicknesses. The map was of considerable value to those who were interested in the question of water carriage throughout he country.

SUBSIDENCE CAUSED BY COLLIERY WORKINGS.

By Joseph Dickinson, F.G.S.

A paper by the present writer giving the result of his observations on subsidence caused by colliery workings was read before the Manchester Geological Society so long ago as November, 1859. Since then additional experience has been obtained and detail introduced for defining the position and extent of the areas required for support, but without coming before this Society. It seems desirable therefore to bring the subject up to date. The 1859 Transactions have long been out of print, and may be unknown to many present members, it may therefore be useful to reopen the

subject by reciting the original monograph, and to include the kindred subject of protecting mines from overlying water. In endeavouring to do so the subject is divided into the following Parts:—

Part I. The 1859 paper on Subsidence.

,, II. Abridgment of evidence on the subject given before the Royal Coal Commission in 1868 and 1869.

,, III. Present views, with Deductions.

PART I.

The 1859 Paper on Subsidence.

In most colliery districts the subject of this paper is of importance. It is especially so in a district like this where coal is worked under a surface extensively intersected with canals and railways, and covered with houses, and with factories containing machinery which should not be disturbed.

The working out of a seam of coal from underneath any extensive area, without leaving sufficient support, naturally causes subsidence. The area over which, and the depths from which this subsidence extends, is the subject which I now propose to bring before the notice of this Society.

It seems to be taken as a common rule by some, that where the strata lie horizontally, subsidence is vertical only; that is, that the surface subsides only immediately over the part where the coal is worked out; and that, where the strata dip at an angle, subsidence is at right angles only to the dip.

As a rough rule this, possibly, serves some ordinary purposes; but it certainly is not founded upon a consideration

of all the circumstances of the cases. On the contrary, subsidences seem to vary with the kind of strata, and the depth and thickness of the seam of coal that is being worked; the subsidence being greatest where the strata are soft and the coal thick, and least where the reverse obtains. In South Staffordshire, for instance, where many of the strata are soft, and a seam of coal varying from 8 to 12 yards thick, called the "thick" or "10-yard coal," is worked (which affords one of the best opportunities of noticing subsidence), it is clearly found that, in horizontal strata, subsidence extends far beyond the working; and the distance to which it extends beyond is known as the "draw" or "pull." The draw or pull, however, is not confined to soft strata and a thick coal. It is common, to some extent, to every stratum when broken to moulder down toward the angle of rest. Subsidence should, therefore, in all ordinary cases be expected to extend beyond the actual working underneath. I think I may say, that by most mining engineers the pull or draw is recognised. It also seems to be recognised by the Railways Clauses Consolidation Act, which requires 30 days notice to be given before workings are allowed within the prescribed distance, or where no distance shall be prescribed, within 40 yards of the property; and if found requisite, workings, except certain communications, may be prohibited within such distances. In very soft strata, and with a thick seam of coal at shallow depths, surface subsidence sometimes extends so far beyond the workings, that instead of the rule referred to being any correct guide it would, with limitation as to depth, be nearer to conclude that the subsidence may extend to an angle of 45° beyond the working. That is to say, that the surface would subside as far beyond the working as it is deep to the working. This, however, seems to be extreme. With ordinary strata and thin seams, it seldom extends one third of the depth.

The slope or hade of faults in ordinary strata is about 1 horizontal to 3 in depth, the fault being generally steeper in hard than in soft strata. With mineral veins, likewise, when the strata traversed are of various degrees of hardness, as in the mountain limestone series of Cumberland, Northumberland, and Durham (where the workings being in the vein, the slope or hade admits of being examined throughout), the slope is found to be flattest in the soft shales, and steepest in the hard siliceous sandstones and limestone. In the shales the slope extends to about 1 horizontal to 1 in depth, and averages about 1 horizontal to 2½ in depth; whilst in the sandstones and limestones the slope is much steeper, being sometimes nearly perpendicular, and averages about 1 horizontal to 5 in depth. These slopes or hades of faults, and mineral veins, are probably the true angles of rest of the particular strata which they traverse, and are apparently the best indication of the limit of probable subsidence.

To leave support, therefore, only under the part of the surface intended to be left undisturbed would be useless. Indeed, it would, generally be worse than useless, as support so left tends to form an apex on the surface, and would occasion more than usual disturbance to buildings. A similar effect is also produced, but in a less degree, where pillars of solid or nearly solid coal are left over a certain space, and then smaller pillars, which become crushed, outside. The whole of the pillars, when the weight to be supported is equal over the whole, should be uniform, and capable of withstanding the pressure; or they had better not be left at all.

With strata dipping at an angle, if the subsidence were always at a right angle to the dip as assumed by the rule referred to, it would follow that when the dip approaches the perpendicular, as it sometimes does, the limit of expected

subsidence would extend far beyond probable bounds. The rule must, therefore, evidently be taken with limitations. The subsidence may be, and doubtless sometimes is, at a right angle to the dip—coinciding with the rule; but this happens only with strata of certain hardness and at a certain dip; and it would not so happen with them were they either harder or softer, or if the dip were either more or less. Up to a certain angle of dip, therefore, in estimating the probable extent of subsidence, additions to a right angle should be made; and when beyond the certain angle, deductions are required.

In no ordinary case that has come under my notice,—no matter how steep the seam may be dipping,—but of course excepting running sand, does the extent of subsidence exceed that which an angle of 45°, set off from a horizontal line, comprises. At that angle, even with very soft strata, the support given by the sides seems to cause the angle of rest to be reached before it would ensue were there no side support. With the 10-yard coal seam alluded to, cracks three or four inches wide are sometimes observable on the surface of the ground where the coal is being worked more than 200 yards deep. With thin seams also, similar cracks are sometimes observable at shallower depths; and occasionally where the coal is all being worked out at once by long work the approach of the face of work is indicated on the surface by an undulation, causing buildings, especially noticeable in engine chimneys, to lean towards the work as it approaches; and as the working passes on underneath the surface subsides and the buildings again resume the original, or nearly the original, position.

When buildings and other works are scattered over the surface, the quantity of the coal seam which would be wasted if left in pillars, often makes it economical to work out the coal under the buildings, unless they be of more

than usual value, and afterwards to level up and repair the damage as the ground becomes consolidated. Where several thin seams are worked, the subsidence may amount to several yards; and it has occasionally caused canal banks to require raising, from time to time, until they have become several yards higher than the surface with which they were originally level.

To avoid unnecessary damage to buildings, when the coal is intended to be worked underneath, various methods are resorted to. One of the most successful is, to previously bind the building together with wood or iron, and keep it so until the coal is removed, and the ground has again become consolidated.

When the buildings are numerous and close together, as in a town, regular pillars are usually left; and where the pillars so left are adequate, and the coal is hard and has a hard floor, the strata above remain undisturbed. But if the pillars are inadequate, or the coal soft, or if the coal is hard but has a soft floor into which the pillars sink, then subsidence ensues; and in such cases more surface damage may be occasioned by leaving pillars than if the whole of the coal were worked out, particularly if in working all out the goaf or gob behind be uniformly packed with rubbish as the working advances.

The proportion of coal requisite to be left, in ordinary cases, when pillars are resorted to, depends upon circumstances such as I have alluded to. The proportion for each case should be decided upon its own circumstances.

The maximum, unless solid coal be left, seldom if ever exceeds two thirds, which allowing for openings made through the pillars, may become somewhat reduced. The proportion usually left is, however, about one half, or a little less than one half, the pillars being made equal in width with the boards or bays; but the openings between the

boards are made through the pillars, which reduces the proportion for pillars to that extent below one half.

When the strata subside, they either do so in a mass, or are more or less broken up. If broken, they do not readily pack again into as small a space as they originally occupied. The surface of the ground may not therefore subside as much as the seam worked out is thick. Some of the portion may be distributed in the greater space occupied by the broken strata between the working and the surface. With a 4-foot seam of coal all worked out at a depth of 200 yards, the subsidence to the surface has by some persons been averaged at 3 feet, and that the proportion decreases as the depth increases, until at 600 yards the subsidence does not reach the surface. The subsidence may, however, be slow in reaching from such a depth, but it may become appreciable and certainly so if the superincumbent strata settle down in a body without being broken.

To those mining engineers whose experience of subsidence from colliery workings has been only of hard strata and thin seams of coal, probably some of these observations—especially those on soft strata and a thick coal—may appear extreme. Instances, however are not wanting where subsidence has occurred when it was supposed proper pillars had been left.

The following discussion took place after the reading of the paper in 1859:—

Mr. William Peace, F.G.S., of Haigh, who presided, invited members to make remarks on the paper, for the results of experience were national wealth. Most of them had had more or less experience of the consequences on the surface of getting coal. He could corroborate the statements of Mr. Dickinson to some extent, although he had not had experience in working thick mines such as those in South Staffordshire, of 10 or 12 yards, or of seams approaching

the perpendicular; in the remarks on which, he coincided with Mr. Dickinson, who had enjoyed extensive opportunities of observation. With regard to subsidence in surface, he could also go with Mr. Dickinson; and as an instance in proof being better than generalities, he mentioned that, to the north of Wigan they had a seam of coal about 4½ feet thick, which had been worked to a depth of about 150 yards, causing a subsidence of a canal about 3½ feet. Mr. Dickinson had given a practical and valuable suggestion with regard to the necessity of mining engineers leaving sufficient pillars for the support of buildings. For instance, supposing the mine to be horizontal, and the seam of coal to be within 2 yards of the surface, probably 5 yards left would be sufficient; if 10 yards, more would have to be left; and so on in proportion. If there were 10 or 12 seams, a building would, in point of fact, be supported on the apex of a pyramid extending with the depth. Another point in Mr. Dickinson's paper deserved consideration. There might be a roof of solid rock 30 yards or 40 yards thick, but it was not certain that the surface would not subside. The superincumbent weight of earth would press the pillars into the soft strata of earth which often underlay the coal, causing the earth to "heave;" showing that the surface must have subsided, or the bottom of the mine could not have risen to the top. In such cases, though buildings might not be injured, a canal, or any hydraulic work, would necessarily receive great damage. Mining engineers working in the neighbourhood of docks, canals, or similar works, would do well to bear this in mind.

Mr. Alfred Hewlett, of Wigan, said his experience confirmed that of Mr. Dickinson. The thickest mine under a town or building, of which he had had experience, was one near Wigan, the seam of which was 7 or 8 feet thick. After going to a depth of about 180 yards, the North Union

Railway, which ran above, settled about 6 feet. There was a large extent of coal, and the roof was very strong, but the floor was very soft. He had noticed that when the roof began to move, it moved very rapidly, and to a great extent; also that the roof "pulled" to a far greater extent than any other he had seen in the district. In working under buildings with this sort of roof, he had often found it safest to take nearly the whole of the seam away, and support the roof substantially.

Mr. Thomas Livesey, Senr., of Oldham, mentioned an instance where the whole of a 3 ft. 6 in. seam had been worked, at a depth of 150 yards, without the house of a weaver, who worked above, sustaining any damage. There was sand upon the mine, and it was probable that the coming in of the sand prevented damage. The land and house might have subsided, but it must have been regular and easy. He also knew of two mines being worked under buildings; one with what was supposed to be very sufficient pillars, but after a few months the buildings were broken to pieces; in the other instance, the whole of the coal was got without damage.

Mr. Ralph Fletcher, Senr., M.A., of Atherton, said he could corroborate this statement. There must be subsidence, but it was gradual.

Mr. Binney, of Manchester, mentioned an important point in reference to deposits of sand and gravel. He had known a mine of about 4 ft. thick worked at a depth of 50 yards, which was covered with about 10 yards of solid brick clay; and to his surprise the "draw" extended from 25 to 30 yards, demolishing about a dozen houses.

Mr. William Peace suggested that the cracks in the clay had become filled with sand, upon which water had

acted. In draining stiff clay land, it was necessary to go 5 or 6 feet deep, from the same cause.

The discussion took a conversational turn, and was joined by Mr. EDWARD HULL, of the Geological Survey; Mr. ANDREW KNOWLES, of Pendlebury; and others.

PART II.

ABRIDGMENT OF THE EVIDENCE ON SUBSIDENCE GIVEN BEFORE THE ROYAL COAL COMMISSION 1868 AND 1869.

The reports published in 1871 show the various subjects comprised by this Commission, of which the Duke of Argyll was the Chairman. The inquiry was divided under respective committees, one being on "Waste in working", of which the writer of this paper was the chairman; and among the points comprised by it was that of coal left for the prevention of subsidence. The evidence was given in 1868 and 1869, by well-known mining engineers, colliery managers, and others, from various parts of the kingdom, most of them having had many opportunities for such observation. The following is an abridgment of the evidence:—

1. Mr. JOHN KNOWLES, of Pendlebury, near Manchester, stated: For shallow mines, where numerous buildings have to be supported, a series of small pillars 4 to 8 yards wide, with similar widths of working, may suffice; but for deep mines, pillars 40 yards wide, with workings 20 yards wide, are required; and if the coal be tender, or the floor soft so that pillars would crush into it, more support is wanted. Indeed if the surface has to be absolutely supported, a sufficient area of solid coal should be left. Mills require careful support. Less suffices for cottages; they generally subside gradually, without being much damaged, and where

not too many together the best way is to take out all the coal. With all worked clear out, the surface soon settles, and in two years becomes safe for building upon. But where pillars are left, the settling takes longer. Subsidence ordinarily extends beyond the workings, increasing in proportion to the depth of the working. The distance of subsidence beyond the working, is called the "draw" or "pull." The surface to be supported is thus the top of a pyramid or truncated cone. With the strata near Manchester, inclined at about 1 in 3½, the draw is nearly all from the dip side of the working, with only a little from the rise side. At this inclination, with these strata, a working 530 yards in depth has been proved to draw the surface on the dip side 170 yards, (being 1 in 3·14 from the perpendicular), beyond the working. The draw is generally taken to be at a right angle to the dip of the seam.

2. Mr. Matthew Truran, of Dowlais, Glamorganshire: The coal on the northern outcrop of the South Wales coalfield, bears pressure very badly. In pillar and stall work, more than 60 per cent. was crushed into small coal. The introduction of longwall effected great saving in this respect. But even with longwall, crushing continued noticeable after stoppages for Sundays and holidays. Very little coal was purposely left for surface support.

3. Mr. Thomas Evans, one of Her Majesty's Inspectors of Mines: The population over many parts of the South Wales coalfield was so thin that only very small quantities of coal were needed for surface support. Near faults, where the coal was rotten, like black soot, it was left unworked.

4. The Right Honorable Lord Mostyn: In his royalties at Mostyn in North Wales, the Cannel, Five Yard, Three Yard, Two Yard, and Durbog seams were being

worked at 200 yards under the estuary of the River Dee. The lease required one half to be left for support. Formerly, where the workings were near the surface, work was stopped for a long time by the sea breaking in.

5. Mr. George Clementson Greenwell, Senr.: In Cheshire, the seams were worked as in Lancashire. In Somersetshire, it was all longwall. Good coal was sometimes left to support a mansion, or temporarily for shafts; but, except in case of adverse interests, all was ordinarily worked under farm houses and cottages; repairs being made when needed. Subsidence varies according to the thickness, and the number of the seams worked, and the kind of strata. For inclined seams, with a dip of 1 in 6, the draw from the dip towards a rise working would be one sixth of the depth; and more would be left to keep the fracture from coming too close. For steeper dips, he concurred with the evidence given by Mr. John Knowles. With some inclinations, dip workings do not draw at all from the rise side. For a horizontal seam, less support is ordinarily required than for an inclined seam. In an exceptional instance, from a slightly inclined mine in South Staffordshire, less than 400 yards in depth, the draw has extended 200 yards beyond the working.

6. Mr. Thomas Wynne, one of Her Majesty's Inspectors of Mines: In the collieries of North Staffordshire at 500 yards in depth, and in Cheshire at 740 yards, there was much crushing. Generally, instead of leaving coal to support a building, it was found best to work all out as quickly as possible.

7. Mr. John Edward Mammatt, of Barnsley: The quantity of coal required for support varied according to the depth, thickness of seam, kind of strata, and the terms of the lease. When allowed, and the coal was more valuable

than the surface property, the coal was worked out, and repairs made if needed. Sometimes, at depths of from 100 to 200 yards, half was taken in widths of 20 to 30 yards, and the other half left. Under part of the town of Barnsley, half had been worked. With a soft floor, it is best to take out gradually.

8. Mr. James Davidson, of Dalkeith, Scotland: The only coal left in Newbattle colliery, was to support the shafts and the day level. In the vicinity of Glasgow, large quantities were left to support the surface.

9. Mr. William Alexander, one of Her Majesty's Inspectors of Mines: The area of coal left for surface support increased in pyramidal form with the depth, and varied with the nature of the strata, and the thickness and number of the seams worked. Whether the seams were horizontal or at an inclination of 1 in 8 or 1 in 6, he had found that leaving one yard to the fathom (1 in 2) sufficed. It might sometimes be too much. Where the coal was all worked out rapidly, working continuously, night and day, buildings were less injured than by working slowly. Bolting the walls of buildings together until the ground became settled, also lessened injury. After longwall working, land was considered fit for building upon in two years; the collapse might be complete after one year, but two years was perhaps soon enough. Where the level of the surface had to be maintained, all the coal was not worked. Railway companies wanting coal left had to pay for it; otherwise it was worked, sometimes only a few fathoms below the railway, the subsidence being adjusted by men in attendance.

10. Mr. George Baker Forster, M.A., of Newcastle-on-Tyne: The coal in Northumberland was ordinarily taken out entirely under cottages; a few pillars might be left under farm houses. Under mansion houses and large

buildings, and when prescribed by the lease, 100 yards was left all round. Where coal exceeded the value of the surface property, all was worked when allowed, and the property rebuilt if needed. With those strata and working on the pillar and board system, the draw was not at a large angle, but was very much affected by faulty ground. The position of coal left for barriers was discernible on the surface. At Elswick, half the coal was left. At Whitehaven, in Cumberland, the 10 ft. seam dipping seaward, was worked three miles under the sea, the extremity of the workings being two miles from the shore. The boards were driven six yards wide, with pillars left at first 20 yards wide. Afterwards, at 60 fathoms and more beneath the sea, the pillars were all taken out; but at less than 60 fathoms, 48 per cent. was left for support.

11. Mr. Thomas L. Cottingham, of Mold, Flintshire: At Neston, on the Cheshire side of the estuary of the river Dee, with the seams dipping towards Mostyn at the rate of 1 in 7, and worked board and pillar system under the estuary, the pillars were nearly all got to within about 30 yards of the surface. The bed of the estuary was sand, with 15 yards of clay below; the clay subsided without breaking.

12. Mr. William Young Craig: At Hanmer colliery, near Mostyn, longwall was tried under the estuary of the river Dee, but had to be given up consequent upon the want of stuff for packing. Pillar and stall work succeeded; 40 per cent. of the coal being left in some seams for support, whilst in others at depths of from 80 to 100 yards all the pillars were taken out. After removing the pillars, swamps showed at low tide, but they soon filled up.

13. Mr. George Fowler, of Hucknall, Nottinghamshire: In Leicestershire and Warwickshire, with longwall, coal

was occasionally left under valuable buildings; but under cottages and farm buildings it was removed, working as rapidly as possible; after which the buildings settled down, some of them being strapped meanwhile. Leaving coal underneath often caused most damage.

14. Mr. JAMES PHILIP BAKER, of Wolverhampton, one of Her Majesty's Inspectors of Mines: In South Staffordshire and Worcestershire, seams to 6 and 8 feet in thickness were worked longwall, occasionally without leaving coal to support the shafts. The Thick coal, varying from 7 to 12 yards in thickness, was at a few places worked longwall; but commonly pillar and stall. In one colliery of 100 acres 54 pits were used in working 12 seams of coal and ironstone. Mining operations caused houses and other buildings to lean in various directions, some being totally destroyed, often resulting in costly litigation. The extent of the subsidence varied with the local circumstances. The ground sometimes broke off suddenly, whilst elsewhere it held together tenaciously. Anomalies set definite rules aside, the angle of rest varied, and opinions differed very much. From the thick coal workings the draw of surface sometimes extended as far as the depth of the working; a notable case being that of a church on a thick bed of sand at West Bromwich. A sandy foundation did not ordinarily affect buildings unless water was run off from the sand.

15. Mr. HERBERT FLETCHER, of Ladyshore, Little Lever, near Bolton: With seams of 6 feet in thickness, the draw was considered to extend equally on all sides of a horizontal working; the distance to which it extended being 1-10th of the depth from the surface, and to the width of area thus found was added a safety margin of 20 yards at each side. Thus—for the depth of 100 yards, the 1-10th of the depth and the margin equalled 30 yards at each side; for

200 yards, 40 yards; for 300 yards, 50 yards; and increasing in the same proportion with greater depths. For inclined seams, specially naming 1 in $3\frac{1}{2}$ to 1 in $2\frac{1}{4}$, the draw laterally and from the dip (but without having any instance to quote from the dip) was taken at 1-10th of the depth with the addition of the 20 yards margin, the same as for horizontal seams; but the draw from the dip caused by rise workings was, (with the same margin of 20 yards to be added) the horizontal distance between the points of intersection of the seam by two lines let fall from the edge of the surface to be protected, one of the lines being drawn a perpendicular, and the other at right angles to the inclination of the seam; the formula to be modified for exceptional circumstances, such as sand, or soft clay. Within the areas thus fixed for support, it was usual, down to certain depths, to work some portion of the area. The proportion of each area left varied—from about half at 200 yards in depth; 2-3rds from 200 to 400 yards; 3-4ths from 400 to 500 yards. Longwall working, if worked rapidly, occasioned very little surface damage, and soon subsided; whilst from pillar and stall working subsidence might continue for 5 years. The responsibility for damage was generally put upon the lessee, which, unless the coal was of a peculiarly valuable kind, held out very little inducement to incur risk from leaving insufficient support.

16. Mr. Isaiah Booth, of Manchester, &c.: The rules mentioned by Mr. Herbert Fletcher, were identical with those followed by certain engineers, but they were not based on science. In Lancashire, when working from 3 to 5 thin seams, at shallow depths, he had, under a town of considerable size with large buildings, got out $\frac{1}{2}$ of the coal, but not more; and sometimes only $\frac{1}{3}$rd for particular buildings, such as machine "shops". The pillars left varied from 6 to 10 yards in width. Breaks now and then showed in a building,

whilst the next one to it remained perfectly sound. This mode of working under buildings and towns was generally successful. Under the town of Wigan, the Cannel coal, with slight dip, at 160 yards in depth, with former workings overlying, was worked out; one half was taken to begin with and, when the openings had become completely closed by subsidence of roof and upheaval of soft floor, the other half was returned to and worked. The town of Chorley, at a depth scarcely averaging 100 yards, was undermined without any damage that would counterbalance the value of the coal. At Mostyn, in North Wales, he worked under the sea, getting ½ of the coal from seams 6, 9, 12 &c., feet in thickness; and would, at depths exceeding 130 yards, have taken the whole but it was forbidden by the lease. Some leases specify what coal shall be left, the lessor thus accepting the liability; but generally the responsibility rests with the lessee, who may leave as much as he likes so long as he pays for one half of the seam.

17. Mr. Charles Binns, of Clay Cross, Derbyshire: The usual system of working in the Derbyshire coalfield was longwall. It was understood at one time that a 30 yard pillar should be left for ordinary buildings; that sometimes sufficed, but not always; and as the pillar often did more harm than good, it was found best to work all out as rapidly as possible; after which the ground usually subsided with little if any mischief. The notice of approaching workings was given to Railway companies; but they generally allowed all the coal to be worked, and took the risk. It was cheaper to adjust, or to put up a new girder bridge, than to buy coal for support.

PART III.

Present Views and Deductions.

The methods set forth in Part II. for defining required areas for support, amplify those originally laid down in the 1859 monograph recited in Part I., and add information on mining underneath water.

From the writer's own observation, and so far as he knows the views of others, some of the moot points mentioned in 1859 have disappeared, and it is now understood apparently by all that extensive working of a seam without leaving adequate support occasions subsidence. Some useful detailed rules have been introduced; but soft clay and sand, from which water may be drained, are still treated exceptionally, and with a few other divergencies remain for settlement.

The subsidence may often be seen beginning near the face of deep workings. Props are usually set to protect the miners, the back rows being drawn when done with. The worked-out part behind is generally wholly or partially packed, according to the quantity of available rubbish. Cracking and squeezing with, if it be a fiery mine, gas fizzing out, may be heard. The roof, when not hard rock, becomes dissevered into small pieces striated by friction which, in rise workings, settle down on the packing or fall in the waste. The overlying strata subside, the floor heaves, until all becomes compressed and the surface above ground is lowered.

The actual limit to which the subsidence extends between the workings and the surface is generally unseen; but the direction may be judged of from the slopes taken by faults and mineral veins and by analogy. The slope of a fault

in horizontal strata averages about 1 in 3·07 from the perpendicular, varying, according to the hardness and cohesion of the strata, from about 1 in 5 in hard rock, to 1 in 3¾ in medium, and 1 in 2½ in soft.

According to the well-known rule, the slope of a fault indicates the direction of the throw. If the downward slope in horizontal strata be away from the perpendicular, the strata beyond are thrown down. The fault in inclined strata maintains the same angle across the bedding of the strata, but the relation of the slope to the perpendicular is changed, the slope becoming flatter with a downthrow to the rise and steeper with a downthrow to the dip. This variation of slope increases until at a certain inclination of strata a downthrow to the dip becomes perpendicular, and afterwards overhangs; a downthrow on the rise flattening proportionately. The direction of the throw is also frequently discernible from the terminal scales of the striations or slickensides which point in opposite directions on the two cheeks of the fault; care being requisite to observe the true cheeks, and not an intermediate fold.

So likewise in certain aspects does the limit to which subsidence extends correlate with the slope of faults. The ground beyond apparently gives some support to the subsided part, and gravity partly counteracts overhanging in steep inclinations, thus causing the extremity of the subsidence to be less steep than the slope of a fault except with thick seams and soft strata; but in all other aspects, in all kinds of strata, the coindication is identical. The angles at which subsidence traverses the bedding of strata vary with the hardness, and the slopes deviate from the perpendicular according to the inclination of the strata, similar to those of faults, as shown in the diagrams: The striations caused by friction also correspond with those of faults and mineral veins.

It is important to observe that the proportions of hard and soft strata vary so considerably even in the same coalfield as to materially affect the extent of subsidence. In Lancashire, for instance, the strata of the lower series are usually harder than those of the middle and upper series. The variations in each series are also important. In a 1400 yards' section of the upper and middle series may be found 438 yards of hard sandstone rock, an average of 31 per cent.; the other being either of medium hardness or soft. But dividing this same section into separate depths of 100 yards each, the proportion of sandstone to other strata in the respective divisions varies from 16 to 53 per cent.

Computations, therefore, of the extent of subsidence based upon the average hardness of strata are open to serious irregularity. The proper allowance for differing thicknesses of workings is similarly complicated, and apparently more difficult to compute. The allowance for overlying soft clay and sand from which water may become drained is also an open question. Opinions vary also as to the desirability or otherwise whether a few small pillars should be left outside the area for support, to become crushed and taper off the surface subsidence.

These fluctuating quantities show the impossibility of finding any unvarying coefficient, and amply account for some of the existing dissimilarities of procedure.

THE METHODS WHOLLY OR PARTLY AGREED UPON for computing the extent of ordinary subsidence and defining the areas for support, have been mainly derived from observations. The first process is to define the extent of the subsidence on all sides of the property to be protected, and from this to delineate by common projection the position and extent of the areas of coal requisite to be left for support. The extent increases in proportion to the depth,

and varies considerably where the strata are inclined, as shown in the accompanying diagrams.

For horizontal seams not exceeding 6 feet in thickness, and with strata of the average hardness of those in Lancashire, the ordinary subsidence is taken as extending on all sides to 1-10th of the depth, and to this a margin is added. The margin is limited by some mining engineers to an additional 1-10th of the depth; but to this others add an arbitrary margin varying to 20 yards in width, for contingencies and to keep subsidence away from the property to be protected, as shown in the diagrams.

Where the strata are softer, the extent of the subsidence alone is sometimes taken at 1-6th or even 1-4th of the depth to the working, whilst for the 10-yard seam and very soft strata of South Staffordshire it is taken as extending to half of the depth or more; one or both of the margins being added in each case.

On the other hand, for hard siliceous rock such as that called quor in South Wales, and for beds of limestone as in parts of Northumberland, and for the partially stratified floating basalt of Scotland, reductions are needed.

For inclined seams, the lateral subsidence is taken to be the same as that for horizontal seams, but the rise and dip subsidences vary according to the inclination. The subsidence on the dip is always more than that on the rise, consequently a larger area for support is required at the rise side. This variation in size of the area is taken to increase only until the angle of rest is attained, after which at steeper inclinations increase ceases on the dip, and nearly all subsidence beyond the working ceases on the rise. With strata of average hardness and workings not exceeding 6 feet, this angle of rest is taken to begin at about the angle of 18 degrees from the horizontal, or an inclination of

1 in 3·07; above which it remains without further change to the angle of 72 degrees, when decrease from the maximum begins and continues up to the perpendicular. This maximum draw between 18 and 72 degrees agrees almost exactly with the proved draw of 1 in 3·14 from the perpendicular given in Part II.

At the very high angles and the perpendicular, in hard strata, subsidence occasionally ceases entirely; but in soft strata it generally extends beyond the perpendicular, in form like the Roman letter V. A fine illustration of entire cessation in hard rock was for many years afforded (and may still be so) at the Berehaven copper mines, where the steep Mountain mine vein, with few middlings or supports of any kind left, was worked out from the surface to nearly 400 yards in depth, the two cheeks standing firm for a long distance, with the open gash between that had to be fenced.

The measure of the distance to which subsidence extends on the dip until the angle of rest is attained, when further increase ceases, is commonly taken to be, 1-10th of the depth added to the horizontal distance between the points of intersection of the seam by two lines diverging from the nearest edge of the property to be supported, one of the lines being perpendicular and the other a rectangle to the inclined plane of the seam.

In measuring this depth of which 1-10th is taken for defining the rise side of the area for support, some engineers take the vertical distance from the nearest part of the surface to the rise side of the area, but others take the longer distance from the edge of the property to be protected down to the seam; the difference in the length of the two lines with a seam lying at 18 degrees being as 0·95106 is to 1·0.

For defining the dip side of the area, the depth of which 1-10th is taken being further on the dip is, of course, always more than that for the rise side.

Another difference sometimes occurs in this computation; some consider that all needful margin is included in the 1-10th of the depth combined with the distance between the intersection by the two lines, especially when the 1-10th of the longer line is taken; but others add an arbitrary margin, varying up to 20 yards, for contingencies and to keep subsidence away from the property to be supported, as shown in the diagrams.

For softer strata and thicker seams, particularly with such as the 10-yard seam and very soft strata of South Staffordshire, proportionately increased modifications are required.

For the hard rocks in South Wales, Northumberland and Scotland, described under the heading for horizontal seams, proportionate reductions are required.

THE AREAS FOR SUPPORT, projected as described, and as shown in the diagrams, have now to be considered; whether the entire area should be left unworked or in pillars. The general opinion appears to be that:—Where the level of the surface has to be absolutely maintained and the superincumbent weight would either crush pillars or force them into the roof or floor, the whole area should be left unworked; otherwise some subsidence will occur; which, if unprovided for by the lease, would leave the lessee open to a claim for compensation.

But where the surface may be lowered and the lessee is liable only for damaged property, and is willing to take the risk, whether because the damage is likely to be less than the value of the coal, or otherwise, it is considered best to work all out; and to work as quickly as possible, preference in most cases, but not always, being given to the longwall system.

If the lessee has no option, but must leave pillars of fixed size, it is now understood that, unless it be specially permitted, the proportion fixed shall be maintained and not reduced by cutthroughs.

WHERE PILLARS ARE LEFT, and the strata are of average hardness and the seam of coal not exceeding 6 feet, the following ratios have proved sufficient:—

For depths to about	150 yards, $\frac{1}{4}$th	to be left in pillars.
Ditto	300 yards, $\frac{1}{2}$	ditto
Ditto	450 yards, $\frac{2}{3}$rds.	ditto

At depths of about 500 yards, pillars become crushed.

Pillars for horizontal seams may be either square or oblong; but for inclined seams, oblong pillars lengthways between rise and dip are preferred, especially where well defined cleavage or slips run level course.

In the 10-yard seam of South Staffordshire, at the present depths of 600 to 700 yards, with only about 1-3rd of the seam taken in the first working, large and dangerous quantities of coal from beyond the faces occasionally burst into the workings; and tremour is sometimes felt aboveground.

Similar outbursts have also occurred since the crushing depth of 500 yards was attained in the thin Royley mine at Nook, near Ashton-under-Lyne; more of the outbursts apparently occurring in narrow workings than in longwall.

TOWNS, SEAS AND OTHER WATERS, have been occasionally undermined, of which the following is a summary of some of the past and present successful and unsuccessful instances:—

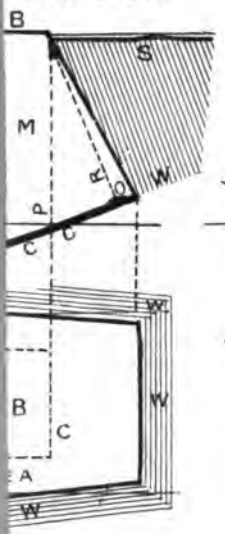
UNDERMINING TOWNS: In Lancashire the town of Chorley stands upon pillars 5 yards square, 3-4ths of a seam of coal 20 to 42 inches thick having been worked at an average

:ERY WORKINGS.

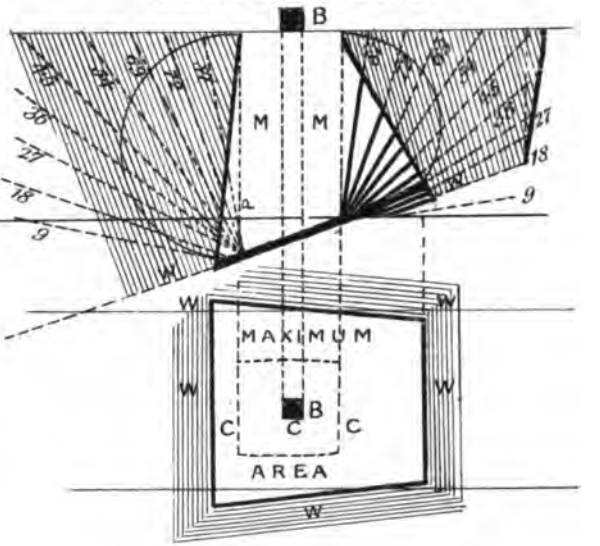
h 1898, by Joseph Dickinson. F.G.S.

ESS AND WORKINGS NOT EXCEEDING 6 FEET.

1 IN 3·07.

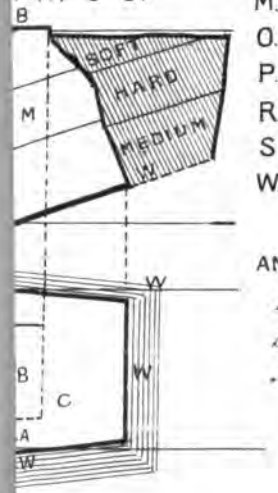


VARIOUS ANGLES.



RSE STRATA

1 IN 3·07.



REFERENCE.

B. *Building to be supported.*
C. *Coal or Pillars for support.*
M. *Margin 10 yards, varying to 20.*
O. *One-tenth of depth.*
P. *Perpendicular.*
R. *Rectangle to Seam.*
S *Subsidence.*
W. *Worked out.*

ANGLES AT WHICH FAULTS TRAVERSE.

Hard Strata, about 1 in 5 perpendicular.
Soft " " 1 in 2½ "
Medium " " 1 in 3¾ "

depth of about 100 yards. Parts of Oldham are on oblong pillars 6 to 10 yards wide, with half of the coal in several seams worked at various depths to about 300 yards. Under Wigan, the whole of the Cannel seam at 160 yards has been worked, with other workings in seams above and below; half was first taken, and afterwards when the workings had become squeezed together, the other half was returned to and worked out. Under some of the outskirts of Manchester, all the coal in some seams has been taken, and in others 1-3rd has been taken and 2-3rds left. In Northumberland, at Elswick half was worked. In Yorkshire, under part of Barnsley half was worked. Many other instances might be added.

UNDER THE SEA AND OTHER WATERS: In South Wales, at Landshipping, in 1844, with cover of only 4 feet of strata and 20 yards of sand, the sea broke in, inclosing 40 persons. In North Wales, under the estuary of the Dee, in Flintshire, work is now going on at Bettisfield; and there have been extensive workings at Mostyn and Hanmer. Those at Mostyn were to the depth of about 250 yards under high-water mark, half being taken; the other half would have been taken in the deep workings but for prohibition by the lease: the sea long ago found entrance into the shallow workings; after which for many years work was resumed; but the sea has since found entrance into both shallow and deep workings, the inlet this time being possibly through some boreholes on the foreshore which were left unpuddled. At Hanmer, adjoining Mostyn, longwall was tried under the estuary, but given up in consequence of the want of stuff for packing and pillar and stall work was resorted to; at some parts 40 per cent. was left for support, but with 80 to 100 yards of cover the pillars were all taken; subsidences showed in the sand and mud at low tide, but they soon filled up.

On the Cheshire side of the estuary, at Neston, with some strata and 15 yards of pliable clay underneath sand, the first workings were 3 yards wide and pillars of the same width; the pillars were afterwards returned to and worked to where the cover was only 30 yards.

In Cumberland, at Whitehaven, in 1868, workings in a 10 foot seam extended 3 miles under the sea, the extremity being 2 miles from the shore; the first drivings were 6 yards wide, with pillars of 20 yards; the pillars where the cover exceeded 120 yards were all taken, certain of those at less than 120 yards being reduced to 48 per cent. At Workington, in 1837, the colliery became inundated by the sea, inclosing 36 persons; the extreme workings at the time were rising towards the bottom of the sea, with about 50 yards between, and pillars were being much reduced.

At the present time, in one case off the coast of Cumberland, the depth at which longwall may be worked is limited to 100 yards in the case of three seams, but if only one of the three seams which are workable is worked, this is reduced to 90 yards.

In Ireland, in the Leinster coalfield, the Jarrow seam has for many years been worked longwall at 57 yards underneath the exhausted and inundated shallow workings of the Kilkenny yard mine.

In Scotland, the Firth of Forth is being undermined, a description of which is given by Mr. H. M. Cadell in Vol. XIV, Trans. Fed. Inst. M.E., 1897.

In Durham and Northumberland: At Newcastle-on-Tyne, the Hutton seam has been worked out at 120 yards below the High Main workings when full of water at high pressure.

The successive inundation of a series of collieries between Newcastle and Jarrow commencing 1811 and ending 1859,

consequent upon water from exhausted workings in the High Main seam finding its way into working collieries; details of which, and the re-opening begun 1867 and still proceeding, described under the heading "Wallsend colliery," by the present Mr. T. E. Forster in the Trans. Fed. Inst. M.E., Vol. XV., Part I., is a useful history in itself.

At the present time, the under-sea coal off the coast of Northumberland, at Cambois and Cowpen; and off the coast of Durham, at Marsden, Monkwearmouth, Ryhope, and Seaham is being worked. The depths vary from 180 yards in the north part to more than 600 yards in the south part; and the seams vary from less than 4 feet to near 8 feet in thickness. The leases have been mostly let on the assumption that the coal will be worked by pillar and stall, and it is left entirely to the Crown agent's judgment as to what widths boards and walls should be driven, and the size of the pillars to be left. The lessees have no power to remove pillars without the sanction of the Crown agent. In some cases special permission has been given to work by the longwall method, and in this case it is stipulated that no seam shall be worked by this system, unless there be 120 yards of cover between the bottom of the sea and the top of the seam of coal being worked; added to which a pair of narrow headings shall be kept 100 yards in advance of the long wall face, and these headings shall be protected by pillars of coal 50 yards on each side, through which the lessees may drive narrow headings for the purpose of opening out the long wall face beyond this 50 yards pillar; these narrow headings through the 50 yards pillar being protected by 20 yards pillars, which may be cut through for ventilation according to the usual and approved custom. These 20 yards pillars may be extracted after the roads are finished with. The lessees must leave a barrier of at least 20 yards of coal against any fault met with of a throw of

more than six yards, or where the cheeks or sides of the fault are more than two feet apart, and may not drive through these barriers against faults except with the main narrow headings in advance of the long wall face. Some of the workings have already extended to about a mile from the coasts.

WATERY SAND AND STRATA, have inundated many collieries, some temporarily and others permanently; mention of two of which will suffice to show the need of care in such cases.

In 1884, at the then Moston colliery, near Manchester, at a part where the workings were 120 yards below the surface, water broke in from the very thick overlying sand, filling entirely the workings in several seams, which still remain inundated; the present colliery being separated by a large fault.

The other instance, similarly disastrous, occurred recently into the deep workings at Castle Eden colliery, in County Durham; the water coming from the unconformable soft watery sandstone underlying the Magnesian limestone, the cause apparently being the thinning off of the coal measures between the working and the watery sandstone. The entire colliery became and still remains inundated.

CONCLUSION: In endeavouring to detail the subject the writer has prominently set forth the opinions of others without disguising his own.

As to ground to be protected, it appears that notwithstanding some diversities of procedure the methods described, aided by mining judgment, have generally served the purpose intended; but on careful scrutiny room seems left for reflection and amendment. Some of what might at first sight be taken for differences may, when all is known, be fairly attributed to risk knowingly run on account of the coal being

of greater value than the probable damage. The real divergencies apparently originate from the experience having been obtained under dissimilar circumstances, such as the thickness of workings, hardness of strata, and of soft clay and running sand, for which, as stated, not any unvarying coefficient can be found. In defining the areas for support, allowance is sometimes properly made for thick beds of either hard or soft strata, but apparently in too many instances an average hardness is taken when the exact proportions are available. The actual proportions are the true guide. In taking these, the rules for the computation which have proved serviceable need not be changed but only varied. Possibly also a check might be advantageously added by making a distinct computation based solely upon the angles at which subsidence traverses the bedding, varying with the hardness of each stratum, similarly with those of faults and mineral veins, as described and as shown in the diagrams. The construction is easy; taking about 2-3rds of each slope with margins, and full slope without margins.

The described precautions against inundation have differed widely, both in the successful and in the unsuccessful results. Of those where water broke in, the thickness of cover varied from only 20 yards of sand with four feet of strata, to as much as 250 yards of nearly all strata, and were similarly numerous where half the coal was left as where all was taken. Whilst of those resulting successfully with all the coal taken, the thickness of cover varied from only 30 yards to 57, 80, 90, 100, 120 yards and more. In some of the instances resulting in the entire loss of the colliery ample warning was given. It is satisfactory, therefore, to find that in some of the present instances of under-sea mining at certain depths, headings in advance are required. This precaution might apparently be advantageously

extended to workings in the vicinity of watery sand, gravel, and unconformable formations. Panel work also, with dams ready for isolating a threatened panel, might sometimes obviate the loss of the whole colliery.

Most of the subject relates to inflexible laws. Circumstances alter cases. But with identical circumstances discord is avoidable. Some of the able members of this Society could give useful information. With their aid uniform procedure may result.

THE PRESIDENT said he thought gentlemen would all be agreed that Mr. Dickinson's paper would form a most interesting and valuable contribution to the work of the Society. Mr. Dickinson had given them the results of a lifetime's observations, and their best thanks were due to him. He moved a vote of thanks to Mr. Dickinson.

Mr. WOODWARD: I have very great pleasure in seconding the proposition that our best thanks be given to Mr. Dickinson for his valuable paper. It is so exhaustive of the subject that we cannot take it in all at once, but I may say that his experience, and the instances he has given, agree very largely with my own. I have spent a considerable amount of time in taking observations upon subsidence from colliery workings. We do not altogether take in what a mine subsidence means in a populous district like that surrounding Manchester. It causes not only trouble and anxiety to mine owners, but also much discomfort to surface occupiers. Houses are pulled about and people are made miserable; cold winds are let in, water pipes are broken, and all kinds of discomfort ensue from our burrowing underground. Not only so, but in a district like this you break water and gas mains, and sewers; you let down railways and

are never out of trouble. I must say Mr. Dickinson's paper is a most admirable one. He bears out thoroughly my own experience, and he adds to it a great deal. From this paper I have learnt a good many things which I was ignorant of before. The subject is one which might give rise to a good deal of discussion, and it would be well, after the paper has been printed, to bring it forward again, so that members may have an opportunity of expressing their views upon it. Personally I should like to say a little about some of the points in the paper. I am situated, as most of you know, in the Irwell valley, where we have a fault running for a very long distance. Mr. Dickinson has prominently mentioned the effect of faults on subsidence, and I think much information might be elicited if, after the paper is in the hands of members, opportunity were given for discussion.

The vote of thanks to Mr. Dickinson was carried by acclamation.

Mr. Walter Evans said: I well remember the paper which Mr. Dickinson gave to this Society in 1859; I was much struck by it, and it set me thinking and afforded me a good deal of information as to the lines of breakage. So far as I have followed the matter out my observations agree remarkably with the suggestions which Mr. Dickinson then made. Anyone who has had opportunities of seeing thick sections of strata, from under which coal has been worked, can hardly fail to have noticed how the various angles of breakage through the harder rocks differ from those through the softer shales. The difference is very marked indeed. I agree with the suggestion of Mr. Woodward; we shall have better facilities for discussing the paper after we have seen it in print and have had an opportunity of digesting it.

Mr. E. Garside: There is one little point I did not perhaps catch in the paper—that was the reference to the percentage

of subsidence that may be expected on the surface from a given thickness below ground. I may say that from my connection with the Dunkirk Collieries, in 1878, I had the opportunity of noticing two seams, 6 feet and 5 feet in thickness, taken out together. I put bench marks on the surface to indicate the effect, ten years later, of these workings. I found in five years 6·8 feet had gone; and five years later I found 8·92 feet gone.

The PRESIDENT: From the original?

Mr. E. GARSIDE: From the original. That is inclusive. Since that observation, some four years ago, I have not found any perceptible movement.

The PRESIDENT: You found 8·92 ft. gone out at a depth of 445 yards. What was the distance between the two seams?

Mr. E. GARSIDE: Fifty yards. I may add that it would have been interesting if we could have been told the ratio, so far as is known, between what is taken out and the degree of surface subsidence.

Mr. H. H. BOLTON (Accrington), who was asked to say a few words, said he had nothing to add to what they had heard with regard to the extent of subsidence. He had enjoyed Mr. Dickinson's paper very much, and was sure it would become a classical paper on the subject. He would like to ask Mr. Dickinson a question as to the case he mentioned of coal worked under Wigan,—where it was taken out in two workings, and in the one case the bottom lifted up till it and the roof met,—whether a subsidence was not observed after both these operations, after the second as well as after the first of the two workings.

Mr. DICKINSON: No doubt there would be two subsidences there. The apparent rising of the flooring to the roof was only caused by the superincumbent strata coming down.

Mr. Bolton: In our own district, whenever we are working near a farmhouse—an old house especially—if it is within a mile, we are always accused of disturbing it. If we were to go by what people say "the angle of rest" would be a very wide one in our strata. It is an angle of unrest rather, for we are always being accused of shaking down old houses. On the hill sides there are many detached farmhouses which it is difficult to locate exactly; and I find from some of the old plans (I do not say that it is so in our time) pillars have been left some distance from where the houses actually stand, and where subsidences have occurred. We have had subsidences especially along the faults where pillars of coal have been left to support buildings. The presence of a fault has upset our calculations, and very often the pillars left have been of no avail at all.

Mr. Dickinson, having acknowledged the vote of thanks, said he felt that he could not add anything to what he had already stated in his paper. All the statements he had made had been carefully studied, and he was sure that the figures given—as several gentlemen had observed—could not be grasped until members saw them in print. If there was to be any discussion, and they were to arrive at any conclusions, it had better be deferred to a future meeting.

The President: I think we are all agreed that that would be the better course.

This concluded the business of the meeting.

INDEX TO VOLUME XXV.

Annual Report, 1895-6 1
" " 1896-7 313
Australia, Evidence of Glacial Action in. By Bernard Hobson, M.Sc., F.G.S. 173

Balance Sheet, 1895-6 5
" " 1896-7.. 318

BARNES, (J., F.G.S.) AND HOLROYD (W. F., F.G.S.): —
Fossils from the Carboniferous Limestone 394
On the occurrence of a Sea Beach at Castleton, Derbyshire, of Carboniferous Limestone Age .. 119, 181, 308
On the occurrence of Lamellibranchiata, Gasteropoda, and Cephalopoda in the Millstone Grit of South Yorkshire.. 184
Some Experiments with regard to the effects of pressure upon decaying vegetable matter 114, 134
The supposed "Calcareous Tufa" at Blackpool 526

BELL, (THOMAS, J.P.) :—
Further remarks on the Durham and Cleveland Salt Districts 69

BIGG-WITHER, (H.) :—
Notes on Electrical Shot-Firing 483

Blackpool.—Supposed occurrence of Tufa in the interglacial deposits. By Robert Humphrey, F.S.A., (Scot.) 494, 526

BOLTON, (HERBERT, F.R.S.E.) :—
Nomenclature of the Seams of the Lancashire Lower Coal Measures 428
Notes on the Pyrites Nodules found in the Maypole Sinkings 240

PAGE

Boring at Bold, near St. Helens.. 112
,, Haverton Hill, Co. Durham 71
,, Seaton Carew 73
British Association.—Report of the Delegate (Mark Stirrup, F.G.S.) at the Liverpool Meeting, 1896 105

CALDWELL, (GEORGE) :—
Notes on Hematite found in the Maypole Sinking Pits 393
Sinking at the Maypole House Colliery, Abram 238

CAPELL, (Rev. G. M.) :—
On the Increase of Fan Gauges in Mine Ventilation of the present day; with some notes on Ventilators.. 194

Castleton.—Occurrence of a Sea Beach of Carboniferous Limestone age. By J. Barnes, F.G.S., and W. F. Holroyd, F.G.S. 119, 181, 308
Remarks on the Sea Beach. By Prof. E. Hull, F.R.S. 306

Coal Bed Formation.—New aspects of. By W. S. Gresley, F.G.S., F.G.S.A. [Abstract.] 525

Coal Industry in the Rhenish-Westphalian Provinces. By Henry Hall, H.M.I.M. 569

Coal Measure Sections in Leicestershire and South Derbyshire, By W. S. Gresley, F.G.S., F.G.S.A. 95

Correlation of the Dover and Somersetshire Coalfields. By G. C. Greenwell, F.G.S., M.Inst.C.E. 378
Discussion on above 510

Council for 1896-7 13
,, 1897-8 329

DAWKINS, (Prof. W. BOYD, M.A., F.R.S., etc.):—
On the History of the Discovery of the South-Eastern Coalfield 155
Recent additions to the Manchester Museum 421

PAGE

Decking Table.—Improved form, for facilitating the loading of Pit Cages. By William Saint, H.M.I.M. 577

Detonators and Detonation. By W. J. Orsman, F.I.C., F.C.S. 257

DICKINSON, (JOSEPH, F.G.S.):—
Subsidence caused by Colliery workings.. 583

Dover Coalfield.—Correlation with the Somersetshire. By G. C. Greenwell, F.G.S., M.Inst.C.E. 378, 510

Dover.—Flooding of a Colliery Shaft at 193

Drawing Timber in Mines—improved apparatus for By D. H. F. Matthews, H.M.I.M. 414

Durham and Cleveland Salt Districts. By Thomas Bell, J.P. 69

Earthquake Tremors. By William Watts, F.G.S. 164

Electrical Shot-firing. By H. Bigg-Wither 483

Evening Meetings.. .. .. 114, 192, 428

Exchanges, List of Societies, etc., 1896 21
Do. do. 1897.. 337

Finland.—Sketch of the Geology of By Mark Stirrup, F.G.S. 501

Fishes, Fossil from the Jarrow Colliery, Ireland 360

Fleuss Breathing Apparatus, the improved By George H. Winstanley, F.G.S. 137

Flooding of a Colliery Shaft at Dover 193

Fossil Remains in the Lancashire Coalfield 581

Gifts to the Society (and see "Library") 568

Glacial Action in Australia. By Bernard Hobson, M.Sc., F.G.S. 173

GREENWELL, (G.C., F.G.S., M.Inst.C.E.):—
On the Correlation of the Dover and Somersetshire Coalfields 378
Discussion on above 510

PAGE

GRESLEY, (W.S., F.G.S., F.G.S.A.):—
New Aspects of Coal Bed formation 525
Remarks on some interesting Coal Measure sections in the Leicestershire and South Derbyshire Coalfield.. 95

HALL, (HENRY, H.M.I.M.):—
On the Coal Industry of the Rhenish-Westphalian Provinces 569
Hamstead Colliery, South Staffordshire.—Irruptions of Coal into the "Thick Coal" Workings at By Frederick G. Meachem, M.E. 83, 398
Hematite in the Maypole Sinking Pits. By G. Caldwell .. 393
HEYWOOD, (JAMES, F.R.S.), the late 357
History of the discovery of the South Eastern Coalfield. By Professor W. Boyd Dawkins, M.A., F.R.S., etc. 155
History (early) of the Manchester Geological Society. By Mark Stirrup, F.G.S. 39
HOBSON, (BERNARD, M.Sc., F.G.S.):—
On evidences of Glacial Action in Australia 173
HOLROYD, (W.F., F.G.S.):—
See Barnes, (J., F.G.S.) and Holroyd, (W.F., F.G.S.)
HOYLE, (W. E., M.A., F.R.S.E.):—
Minerals from the Nickel Mines of Sudbury, Ontario .. 426
HULL, (Prof. E., F.R.S.):—
Note on the Sea Beach at Castleton 306
HUMPHREY, (ROBERT, F.S.A., Scot.):—
Occurrence of supposed Calcareous Tufa in the interglacial deposits at Blackpool 494, 526

International Congress of Geologists 37, 194, 501
Irruptions of Coal into the "Thick Coal" Workings at Hamstead Colliery, South Staffordshire. By Frederick G. Meachem, M.E. 83, 398

PAGE

Lancashire Coalfield, Fossil Remains in 581

Library.—Additions 38, 153

" " 1895-6 14

" " 1896-7 330

LLOYD, (HERBERT, C.E., M.E.) :—

On the Mineral Resources of the Middleburg District of the Transvaal 474

Lower Coal Measures of Lancashire.—Nomenclature of the Seams of. By Herbert Bolton, F.R.S.E. 428

Manchester Geological Society, Early History of. By Mark Stirrup, F.G.S. 39

Marine Erosion, Effects of. By Mark Stirrup, F.G.S. 192

MATHEWS, (D. H. F., H.M.I.M.) :—

On an improved appliance for drawing Timber in Mines 414

Maypole House Colliery Sinking. By George Caldwell. .. 238

" " " " Analysis of Water. By W. J. Orsman, F.I.C., F.C.S. 239

" " " " Hematite found in. By George Caldwell 393

" " " " Pyrites Nodules found in. By Herbert Bolton, F.R.S.E. 240

MEACHEM, (FREDERICK G., M.E.) :—

On Irruptions of Coal into the "Thick Coal" Workings at Hamstead Colliery, South Staffordshire 83

Further notes on the above 398

Member, Honorary, (Mr. George Wild) 321, 359

Members, List of, 1896.. 27

" " 1897 344

" New ..1, 12, 69, 133, 153, 237, 257, 273, 321, 327, 360, 377, 397, 473, 509, 529, 569, 581

Millstone Grit of South Yorkshire, Occurrence of Mollusca in. By J. Barnes, F.G.S., and W. F. Holroyd, F.G.S. 184

PAGE

Minerals from the Nickel Mines of Sudbury, Ontario. By W. E. Hoyle, M.A., F.R.S.E... 426

Mineral resources of the Middleburg District of the Transvaal. By Herbert Lloyd, C.E., M.E. 474

Museum, Manchester.—Additions to 421

Navigable Waterways, Map of.. 583

Nomenclature of the Seams in the Lower Coal Measures of Lancashire. By Herbert Bolton, F.R.S.E. 428

Nook Pits, Ashton-under-Lyne, Coal Outbursts at 89

Northwich, Rock Salt Deposits at, and the Result of their Exploitation. By Thomas Ward, J.P., F.G.S. 274, 530

ORSMAN, (W. J., F.I.C., F.C.S.) :—

Analysis of Water in the Maypole House Pit, Abram .. 239

Detonators and Detonation 257

Papers and Communications.—List for 1895-6 11

" " " 1896-7 325

Peat, Notes on Slipping, Ireland. By W. Watts, F.G.S. 165

Permo-Carboniferous Boundary. By C. E. DeRance, Assoc. Inst.C.E., F.G.S., etc. 207

Photographs, Prints, etc., Exhibited by S. S. Platt, M.I.C.E., F.G.S. 255

PLATT, (S. S., M.I.C.E., F.G.S.) :—

Exhibition of Geological Photographs, etc. 255

President's Address, 1896 :—The early history of the Manchester Geological Society, with some remarks on Speculative Geology. By Mark Stirrup, F.G.S. 39

President's Address, 1897 :—The utility of Association for the promotion of Science, and of its applications. By John Ridyard, F.G.S 363

Presidents, Past 26, 343

PAGE

Pressure, effects on Vegetable Matter. By J. Barnes, F.G.S., and W. F. Holroyd, F.G.S. 114, 134

Pyrites Nodules in the Maypole Sinking Pits 238, 240

RANCE, (C. E. De, Assoc.M.Inst.C.E., F.G.S., etc.) :—

On the Permo-Carboniferous Boundary 207

RIDYARD, (JOHN, F.G.S.) :—

Presidential Address. The utility of Association for the promotion of Science and of its applications 363

Rock Salt Deposits of Northwich, Cheshire, and the results of their exploitation. By Thomas Ward, J.P., F.G.S. 274, 530

SAINT, (WILLIAM, H.M.I.M.) :—

On an improved Decking Table for facilitating the loading of Pit Cages 577

Salt Districts of Durham and Cleveland. By T. Bell, J.P.. 69

Salt, Deposits at Northwich, and the results of their exploitation. By Thomas Ward, J.P., F.G.S. .. 274, 530

Sea Beach of Carboniferous Age at Castleton, Derbyshire. By J. Barnes, F.G.S., and W. F. Holroyd, F.G.S. 119, 181, 308

Sea Beach of Carboniferous Age at Castleton, By Professor E. Hull, F.R.S. 306

Shot-firing, Electrical. By H. Bigg-Wither 483

Societies, etc., which exchange Transactions.. .. .. 21, 337

South Eastern Coalfield—History of the Discovery of. By By Professor W. Boyd Dawkins, M.A., F.R.S., etc. .. 155

STIRRUP, (MARK, F.G.S.) :—

Effects of Marine Erosion as shown by the Sea Cliffs and Sea Caves of the British Isles 192

Presidential Address. The Early History of the Manchester Geological Society, with some remarks on Speculative Geology 39

[illegible]

[illegible]

[illegible]

14 DAY USE
RETURN TO DESK FROM WHICH BORROWED

EARTH SCIENCES LIBRARY
This book is due on the last date stamped below, or
on the date to which renewed.
Renewed books are subject to immediate recall.

LD 21-40m-1,'68
(H7452s10)476

General Library
University of California
Berkeley

U.C. BERKELEY LIBRARIES
C033817061

204